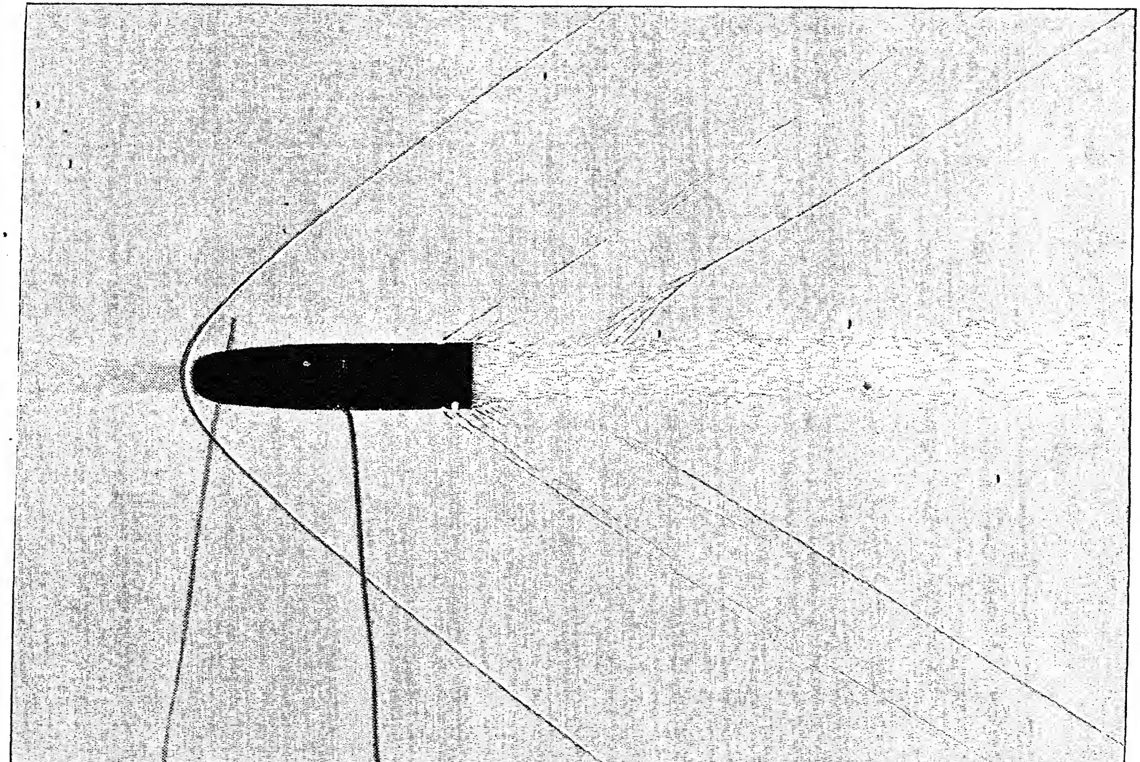

Lee Metford Service bullet in flight. Weight, 215 grains. Velocity, 2,000 feet per second. See page 134.

NOTES ON THE RIFLE.

BY

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LIST OF ILLUSTRATIONS.

PREFACE.

THE present book consists of the substance of a series of articles written within the last twelve months for *Baily's Magazine.* These have been revised and partly re-arranged, and some small quantity of new matter added. The author's object has been to touch upon the principal points of interest connected with his subject, and especially to give some simple account of those more recent developments which at the present time have a very practical interest for the sportsman. He has therefore made no attempt to deal exhaustively with his subject in general, and has abstained from giving any figures or calculations beyond those absolutely necessary to bring out clearly the points which he wished to present to his readers.

He would here gratefully acknowledge the assistance which the experience and kindness of many shooting friends has at all times afforded him, and of which he has availed

himself in the present "Notes." The names of Mr. W. E. Metford and Sir Henry Halford must especially be mentioned in this connection. The author's special thanks are also due to Mr. Kinsley D. Doyle, of the Royal Small Arms Factory, Enfield Lock, for kindly placing at his disposal the pictures of flying bullets which accompany this volume.

April, 1896. T. F. F.

NOTES ON THE RIFLE.

CHAPTER I.

Of Early Weapons.

The accuracy and perfection of modern workmanship, aided as it is by machinery and an increased command over material, has in these days revived and perfected many inventions which had for long been recognised as being of very great advantage, though lying dormant and undeveloped. This is conspicuously the case with firearms. Long and doubtful was the contest before "villainous saltpetre" established its superiority over the longbow and other mediæval weapons. So far back as the time of Henry VIII. a law was passed, with a view to the defence of the country, which declared it lawful "for all the inhabitants of cities, boroughs and market towns of this realm of England to shoot with any handgun, demekake, or hagbut at any butt or bank of earth," such handgun to be "of the length

of one whole yard and not under." And yet the exercise of shooting with the longbow was encouraged by legislation in the reign of Charles I., so that it was still at that time by no means an obsolete arm.

So late as the end of the sixteenth century, when the use of gunpowder had been practised for more than 200 years, there were still good Conservatives who maintained that the matchlock was a weapon much less effective than the bow, and with only one point in its favour—the "moral effect" produced by the noise it made. And yet long before this time breechloading cannon of small calibre (and very unsatisfactory weapons they must have been) had been made in considerable numbers. They commonly had an oblong block fitted with handles, which dropped into a receptacle at the breech end of the barrel, and was wedged fast. This contained the powder charge, the ball being inserted into the barrel in front of it. We also find shoulder-guns of very early date constructed on the principle of the revolver. In the Museum of Arms at Tokio may be seen breech-loading ordnance, said to have been made in Corea, and some of them are attributed to a date before 1550 A.D. The design of these, which has been perpetuated in the East almost until the present

day, is in general much like that of the early European ordnance, and their production was probably the result of European teaching and influence. However that may be, it would seem that Corea, in these days a synonym for benighted ignorance and helpless stagnation, must then have been comparatively enlightened and ahead of her times. The guns of the *Mary Rose*, which was sunk off Spithead in 1545, were recovered in 1836, and their remains may now be seen in the Museum of the Royal United Service Institution, Whitehall. Some of them were breechloaders of 8 in. calibre, and nearly 10 ft. long, made of iron. There is at Woolwich a rifled barrel fitted for breechloading, and bearing the date 1547. But it would seem that in the course of time the early breechloader, which must always have been troublesome and dangerous in practice, disappeared as irreconcilable with the demand for an increased velocity and range of projectile, and, in spite of many attempts to revive the principle, to have remained practically in abeyance for somewhere about 200 years. It was only when the increased production of steel, and improved means of working it, with the aid of the important invention of the percussion cap, enabled the problem to be attacked under more advan-

tageous conditions, that all difficulties were at last surmounted, and the breechloading principle became paramount. Indeed, it is only in very recent years that it has been found possible to extend it to cannon of the larger sizes.

It is, then, perhaps, hardly to be wondered at that the superiority of the grooved or rifled barrel over the smooth bore should have been so long in obtaining general recognition. The germ of this invention is said to have been traced back to the end of the fifteenth century, and to have consisted in straight grooves cut in the barrel, probably with the object of receiving the fouling of the powder, and rendering easier the process of loading. Tradition ascribes the invention of the spiral grooving to one Koster, of Nüremberg, early in the sixteenth century. It will probably never be known whether the spiral groove was an accidental discovery or a deliberate invention. That it should have been the former seems unlikely enough; but it does not at the first glance seem probable that the spinning of the bullet by this means should have been intended.

Still, it must not be forgotten that both in the feathered arrow and in the throwing-spear the advantage of a spin to ensure steadiness in flight had for centuries been recognised. Even

the first man, who in the dawn of the "Stone Age" threw from the hand a flattish stone of a size to be easily grasped in the fingers, no doubt spun it unconsciously as it quitted his grasp, and the steadying effect of the spin upon the flight of such missiles must soon have been noted. We might expect that some attempt would be made to apply so well-known a principle in connection with the invention of fire-arms, and it must be quite possible that the experiment of giving the desired spin by means of spiral grooving may have been deliberately made. To return to less speculative ground, it seems to have been only after the year 1600 that rifling, although not unknown before that date, came into vogue in this country. There is recorded the granting of a patent in 1635 to one Arnold Rotsipen for an invention of a method of rifling small-arms; but, for many years, the use of the rifle does not seem to have become general. The smooth-bore musket, in fact, long maintained its advantage as a military arm. With the rifle it was necessary to have a tightly-fitting bullet, so that the grooves might guide it as it passed up the barrel, and when fouling began to accumulate, the difficulty of loading became extreme.

At the beginning of the present century, when the 95th Regiment (now the Rifle Bri-

gade) was raised, the men were supplied with wooden mallets to drive the soft spherical ball into the grooving; but we are not surprised to learn that they were found inconvenient, and the use of them soon discontinued. The head of the ramrod, indeed, was an instrument powerful enough to force the ball into the barrel, though at the cost, frequently enough, of distorting its shape so as to destroy its accuracy of flight. This difficulty did not arise with the musket, which had a more loosely-fitting ball. It is said, indeed, that the Duke of Wellington was in favour of having a large-bore musket for the British army, so that if any of the enemy's ammunition were captured, their bullets, being smaller, could be made use of, while no musket balls of ours would be of any use to the enemy.

In fact, the ranges were so short, and the inaccuracy of the musket so incurable, as to make it comparatively immaterial whether the projectiles fitted the bore. It is no wonder then that the ingenious author of "Scloppetaria," in 1808, entering into a calculation of the advantages of the rifle over the musket, admits that "a musket will fire three shots to one from a rifle, as generally used," and takes the time necessary to load for a single shot at a minute and a-half or two minutes. What a contrast to the rapidity which we have attained,

we moderns, whose magazine rifles will fire ten shots in a quarter of a minute, and with whom a chief difficulty in war is the maintenance of the ammunition supply!

Truly was the future of the rifle read by Robins, the first scientific investigator of gunnery, who declared, in his "New Principles of Gunnery" (1742), that "Whatever State shall thoroughly comprehend the nature and advantages of rifled barrel pieces, and, having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them, will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall but little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of firearms." Is there not intentional irony in these last words? For surely of all authenticated human feats none can equal the legendary.

Tradition is too often led by an innate love of the marvellous into treating some exceptional and accidental performance as usual. To some such origin we must attribute the statement, gravely accepted by the author of "Scloppetaria," that "the American Indians on the

Western Coast keep as trophies narrow boards fired at by their ancestors, at from 100 to 140 yards, each sitting on them alternately, and holding one of them between his legs while the other fired." It was only (please to observe) the heroic ancestors of the Indians—not the Indians themselves—who were capable of this feat, which, we are gravely warned, "is not mentioned to be imitated by more civilised shooters." So, too, Hans Busk's statement in 1860 that Captain Minié (the inventor of the Minié rifle and bullet) "will himself undertake to hit a man at a distance of 1,420 yards three times out of five shots" may possibly represent that in a few consecutive shots on some one occasion the accuracy had been sufficient for this, but can hardly be taken to mean that Captain Minié was in the habit of expecting frequently, or under any but the most favourable conditions, to perform with such extraordinary success.

It was as late as 1854, more than ninety years after Robins had written the prophecy above quoted, before the adoption of the Enfield rifle for the British Army, and the discarding of the Brown Bess which had been for so many years in the hands of our troops. For the advantages of the rifle in its early days were much more pronounced for sporting than for

military purposes. For the former, the accuracy of each shot fired was of the very greatest importance, and the rifles of the last century, taking as they did a very small charge of powder, and a spherical ball, were capable of great precision up to the distance at which they were used. But this distance was very limited. Says Ezekiel Baker, an advanced gunmaker of his time, so late as 1825, "I have found 200 yards the greatest range I can fire to with any certainty. At 300 yards I have fired very well at times when the wind has been calm. At 400 and 500 yards I have frequently fired, and I have sometimes struck the object, though, having aimed as nearly as possible at the same point, I have found it to vary very much from the object intended." Nowadays, 500 yards is, for target purposes, rather a short than a long distance, thanks to increased velocities and an elongated bullet.

The writer very well recollects, some years since, going out to try to kill a fallow buck in a deer park in the North of England. He was provided by the keeper with the rifle he commonly used, which had probably served the same purpose for sixty years or more—a muzzle-loader of large calibre with many deep grooves, taking a heavy round ball and a small charge of powder. A few sighting shots at a

bit of cardboard showed that the accuracy was good, but the trajectory was so curved that, beyond about thirty yards, a very nice judgment of distance was required to make correct allowance for the rapid drop of the bullet. Part of the problem was to shoot the buck only in the head, so as not to spoil the venison. It is not easy to get very close to the particular buck wanted in a herd, nor must any risk be run of injuring the wrong animal. After sundry hours spent in getting three or four shots, at distances varying, perhaps, from 40 to 70 yards, but which it seemed impossible to judge so accurately as was required for this antique weapon, one of Holland's ·380 rook rifles was requisitioned from a house in the neighbourhood, and, after a few sighting-shots at a mark, the first stalk was successful, and the buck fell with a bullet in the brain at about 70 yards. So much more effective was the modern, and apparently more feeble, weapon.

The rifles of a hundred years ago, great as were the feats which they were capable of performing, neither inflicted on dangerous game the crushing blow of the modern "Express," nor were capable of rapidly repeating it. Hence, perhaps, mainly, such reputations as that of the grizzly bear, which a solitary hunter, armed with a single Kentucky pea-

rifle, must have been a bold man to attack. Hence, too, the stories—which, ridiculous as they may appear to us, represented a very real fact—of crocodile and rhinoceros whose armoured skin was impenetrable to bullets. To kill an elephant must have seemed almost beyond the power of a single man, for the execution of poor Chunie, Mr. Cross's great elephant, at the Royal Menagerie in Exeter Change, as related by Buckland in the third volume of his "Curiosities of Natural History," needed the exertions, first of two sportsmen, and then of a detachment of soldiers from Somerset House, who seem to have kept up a continuous fire at very close quarters for quite a long time before the murder was complete. And this only seventy years ago! Poor Chunie! he was only suffering from toothache, not from madness; and the remembrance of his death will ever remain a disgrace to the nineteenth century. His memory better deserves to be perpetuated than that of the great Jumbo, whose departure from this country the astute Barnum contrived to surround with a halo of sentiment, created, it would seem, by deliberate ingenuity.

CHAPTER II.

Of the Positions.

The illustrations which accompany the present chapter are reproduced from an old book, "Remarks on Rifle Guns," written by the gunmaker Ezekiel Baker, quite at the beginning of the century, when the Volunteer movement had become widespread in the country under the fear of invasion by Napoleon I. He gives four coloured plates of the positions for firing, which are those of standing, kneeling, lying forward, and lying on the back. The two latter are here reproduced, as being the most remarkable. In all the plates the figure is that of a Volunteer of the day, clad in a grass-green uniform, close-fitting to the limbs, the coat being left unbuttoned. His boots reach halfway up the calf; on his head is a high-crowned black hat with a moderately wide brim; a tall green plume, in shape like a fox's brush, rising high above the crown, gives a commanding appearance and adds finish to the figure. Over

RIFLEMAN PRESENTING.

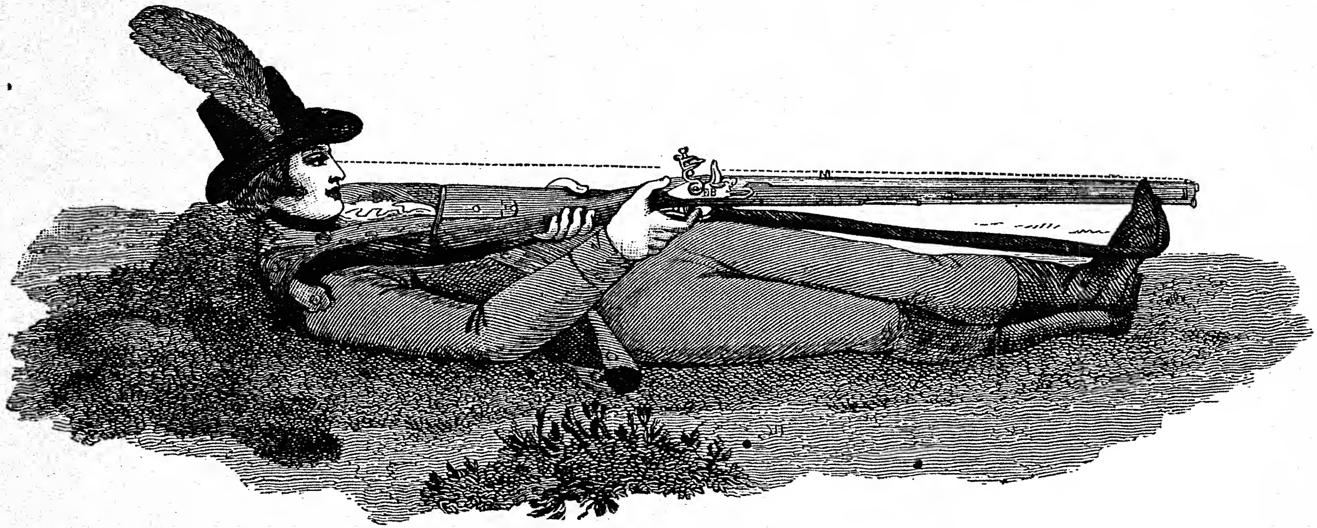
I.—Prone Position.

From E. Baker's "Remarks on Rifle Guns."

his left shoulder the marksman wears the cross-belt which carries his ammunition pouch. When he fires standing, he puts the left hand moderately well forward, and steadies his aim—as is often done by the modern Volunteer—by tightening the sling of the rifle round his left elbow. In shooting kneeling, he goes down upon the right knee and rests his elbow upon the left, but makes no attempt to sit, as is the modern fashion, upon the heel of the right foot. When he lies down in the forward position, the utility of the hat becomes manifest. It will be seen that he applies an excellent principle—that of obtaining whenever possible some means of steadying the aim—with admirable ingenuity, for he rests his rifle upon the crown of his hat, placed for this purpose on the ground in front of him. The thought has often occurred to the writer that the modern spiked helmet would afford a still more suitable rest than the old high hat. It is practically impossible for a soldier to fire in the prone position without taking off his helmet, as it has so deep a brim behind that when he lies down and raises his head the helmet is at once tilted over his eyes. So he has to remove it. And for what purpose can Providence possibly have endowed the helmet with a spike but that the spike should be firmly stuck into the ground

and the rifle rested upon the helmet's inverted rim? Surely it is strange that the real meaning and object of the beautiful adaptation of means to an end thus shown in the case of the Common Helmet should so long have escaped the notice of the military authorities! Let us hope that they may waken, before it is too late, to a sense of the fitness of things in this matter!

The second of the plates now given is, perhaps, still more curious than the first. It will be seen that the Volunteer is lying on his back, and resting the barrel of his rifle upon the toes of the right foot, while the left foot is thrust into the shortened sling, and so takes the recoil. Both hands are thus at liberty to steady the rifle, but the head is unsupported. This position was, no doubt, intended to give great steadiness; but unfortunately Baker omits to give his opinion on its value, and indeed, omits all reference to it. The author of "Sclopetaria," however, in referring to the plates in Baker's book showing the positions used in shooting, says of this one, "As the position is not only awkward but painful, this method is very seldom used as a position of practice," and mentions that he considers it to be unsuitable to the use of what we now call aperture or pinhole sights. It would be curious to know at



RIFLEMAN PRESENTING.

II.—Back Position.

From E. Baker's "Remarks on Rifle Guns,"

what time the back position first came into use. In Baker's day it was certainly no novelty. Mention is made of it in the account of one Colonel Ferguson, given in the "History of the War in America between Great Britain and her Colonies" (Dublin 1785). The whole passage may be quoted as being of interest for the strong testimony it bears to the great effect a century ago of skilled marksmanship with the rifle. Colonel Ferguson was an active and capable officer who met his fate in 1780, when sent by Lord Cornwallis on an expedition into North Carolina with a corps of light infantry and a body of militia of his own training. "The fall of this officer," says the work above referred to, "who possessed very distinguished talents as a partisan, and in the conduct of irregular warfare, was, independently even of his detachment, no small loss to the service. He was perhaps the best marksman living; and probably brought the art of rifle shooting to its highest point of perfection. He even invented a gun of that kind upon a new construction, which was said to have far exceeded in facility and execution anything of the sort before known; and he is said to have greatly outdone even the American Indians, in the adroitness and quickness of firing and loading, and in the certainty of hitting the mark,

lying upon the back, or belly, and every other possible position of the body. It is not certain, that these improvements produced all the effect in real service, which had been expected, from those astonishing specimens of them that were displayed in England. Humanity cannot, however, but wish that this barbarous mode of hostility, was by universal consent banished from the warfare of all nations. It has been reported, that George Washington owed his life at the battle of Germantown to this gentleman's total ignorance of his person; as he had him sufficiently within reach and view during that action for the purpose."

Owing, no doubt, to the difficulties and discomforts which it presents to those to whom it is a novelty, the back position would seem to have passed out of use, and entirely to have disappeared for something like a quarter of a century before 1860, when the National Rifle Association's meetings were first established at Wimbledon. Then it was revived by two or three of the most ingenious of the marksmen of the time, but it did not come generally into fashion until the success, in the early International matches, of the American riflemen who had adopted it, had thoroughly proved its efficacy as a part of the process for the manufacture of bull's-eyes at long distances. Then the

marksmen of Great Britain took it up seriously for the same purpose, and it has been recognised ever since as the steadiest position for match shooting. When the difficulty of keeping the sights upright—always a fertile source of error, and in this position especially difficult to avoid—has once been overcome, it will produce the very highest results of which the rifle is capable. The back position even so far obtained official recognition as to make a fleeting appearance in one edition of the official "Musketry Instruction" handbook. But it has now disappeared from that publication, no doubt because the back of Tommy Atkins, when he is carrying any sort of equipment, cannot possibly come within several inches of the ground.

Anyone who has watched the progress of the annual match for the Elcho Shield between teams representing England, Scotland, and Ireland at Bisley, knows that no one in any of the teams uses any other than the back position, which has a special advantage on occasions when a strong wind is blowing. In 1895 the match was shot, as has sometimes been the case in previous years, in rather more than half a gale, when no pair of arms, however strong, could have held a rifle steadily enough to make accurate shooting. The back position needs perhaps more practice to acquire it in the first

instance than any other. On the other hand, when once mastered it requires no practice, but can be picked up again at once after many months of disuse. This is because unlike the more strictly military positions, it in no way demands any special condition of the muscles. It is sometimes described by those unfamiliar with it as "lying on the back and tying the legs into a knot." But it is really hardly—in any of its forms—so elaborate as this. The only physical qualification necessary for it is a negative one—that a man should not carry so much bulk in his "lower chest" as to obscure his view of the target. The recoil of the rifle is usually taken by putting the butt into the armpit, while the barrel rests upon the inside of the right knee, the right leg being hooked tightly round the left leg (which is drawn up for the purpose until the lower part of it is upright) and resting upon the left instep. But it is also possible to support the barrel upon the side of the leg, or even on the toe of the boot —though this last variation is not to be recommended as particularly elegant or graceful. Also it matters but little whether one hand is spared from holding the rifle to support the head. The fact, however, remains, that, in spite of its advantages, the occasions on which, either in war or in sport, the back position can be used must always be very exceptional.

Of the standing and prone positions much might be said; but they are too well known to need to be dwelt on here. The sitting position, which is perhaps quite as useful for practical work as any, is to be found as a "cavalry" position in the Red Book, and is both easier to learn and more generally available than the Hythe kneeling position, which is not well suited for steep ground. The latter is, of course, impossible for cavalry; imagination shudders at the consequences to the man who, wearing spurs, should try to sit upon his heel. At the Bisley meeting all the above-mentioned positions may be seen in use in the various competitions. The different positions used in target shooting need not be further discussed here. Those interested in the subject will find them very fully described in Mr. A. G. Foulkes's book on the "Theory and Practice of Target Shooting," and in other works.

CHAPTER III.

Of Sighting.

While for purposes of competition and in the practice of military shooting it is found necessary to forbid the use of any artificial rest, the golden rule remains that in the field any support which will help to steady the rifle is an assistance by no means to be despised, especially when, it may be, the whole frame is heaving and throbbing with the lungs and heart after violent exertion, or when, under easier physical circumstances, the anxiety of the shot proves trying to the nerves. Yet there is a warning to be given here. When the circumstances demand very great accuracy it is not wise to depart much from the accustomed method of holding the rifle. It is a well-established fact that the recoil of a rifle or gun does actually begin while the bullet or charge of shot is travelling up the barrel, and that when it leaves the muzzle the barrel is actually in a state of movement. The direc-

tion in which the shot is discharged thus depends to a certain extent upon the point towards which the muzzle is directed, at the instant when the projectile leaves it, under the influence of the stress given by the explosion. It is, for instance, quite well known that a short-barrelled pistol tends to throw its shots high, and requires a high foresight to make allowance for this tendency. Similarly, in a double gun, the barrels are set so as to converge at the muzzle end, because the jerk of the explosion in each barrel tends to move it sideways and outwards from the line of aim. We need not here go into the cause of the upward and sideways motions of the barrel, beyond observing that they depend upon the point of resistance to the recoil not being in a line directly behind the charge. But it is clear that whatever affects the direction or speed of motion of the muzzle will alter the point in its travel at which it will have arrived when the shot quits it. This is why, if the weight of the bullet be varied, as is, for instance, the case where both solid and hollow bullets are to be used in an Express rifle, the sighting required for any distance will also vary. And that the motion of the muzzle does vary, not only with the charge, but also with the manner of holding the rifle, is very

well established. If a carefully-sighted rifle, especially one having a long, light barrel, and firing a heavy charge, be rested at a point near the muzzle, instead of being held in the usual manner by the hand, it will be found to throw the bullet to a slightly different place with precisely the same charge. A rifle with the sights adjusted to shoot true when rested on a sand bag will probably not be truly sighted when held in the hands in the ordinary way. There is often a very considerable difference in the "personal equation" as between one man and another, due mainly to differences of eye-sight and of the manner of aiming, but also due to the manner of grasping the rifle. This is why in many cases a rifle which has been "accurately sighted" by its maker or vendor is found on trial by the purchaser to need alteration before he can get it to shoot truly to its sights. And so if the rifle be supported or grasped or strained in some unaccustomed manner while aim is being taken, the bullet may probably not fly quite truly to the accustomed sighting.

It is very well known that rifles require varied sighting to shoot varied charges, owing to the difference which occurs with them in the "jump" of the barrel. Here is a rather startling illustration of this from experience. A

·360 rook rifle of Holland's make, which was oversighted so that normally aim had to be taken, at 50 yards, six inches below the object to be struck, had the powder charge in the cartridges increased by some 50 per cent. It would naturally have been supposed that, because the larger charge must drive the bullet faster, it would fall less in its flight and strike higher, so that aim would have to be taken at a point still lower than before. But, in fact, the effect of the alteration was found to be this, that aim had to be taken, not as before, six inches below the point to be struck, but full upon it; and that the bullet, owing to some different movement of the barrel under the heavier explosion of an increased quantity of powder, was started on its course in a different direction, and one lower in relation to the sighting of the rifle than that which it had before taken. It is, therefore, not by any means safe to conclude that because one charge appears to shoot higher than another, it is therefore a "stronger" charge.

The adoption of cordite for the Magazine rifle brought out one very curious point connected with "jump." When first issued, the Lee-Metford was used with a charge of compressed black powder. When the cordite ammunition was introduced, it was found that the

rifles shot with it to the left of the straight line above the centre of the barrel, which had given the correct line of aim for black powder. Consequently, the foresight of our Army rifles is now put nearly $2\frac{1}{2}$ hundredths of an inch to the left of the middle line of the barrel—an amount which represents about 7 inches at 200 yards. No satisfactory explanation has as yet been given of this difference in behaviour between the charges of black and smokeless powder. It is clearly in some way due to "jump." There seems a great probability that the extra weight of the projecting bolthead on the right side of the rifle may be connected with the throw to the left with cordite. But it is hard to understand why it should exert an effective influence with one powder and not with another. Then, again, the writer's experience leads him to believe that the amount of the side throw depends to a great extent on the way in which the rifle is grasped. He has found it most marked when shooting in the prone position, more than in standing or kneeling, while it seems largely to disappear when the back position is used.

It is well known that the Martini-Henry rifle, with the bayonet fixed, throws its shots considerably to the left, the weight of the bayonet being on the right side of the rifle. To

avoid a similar lateral deflection, the bayonet of the present Service rifle is attached below the barrel, and so only causes it to shoot rather higher.

We must now notice briefly a very important matter—the question of the best form of sights. Here the golden rules are few, and experience, habit, and fancy go for very much. The cardinal point is to have such sights as will enable accuracy to be combined with rapidity of aim. It is easy to carry refinement of sights much too far. Many of the cross-bows and bullet-bows of our forefathers had aperture or "pin-hole" backsights and adjustable foresights far more delicate than the accuracy of the weapons really required. Even with the best modern rifles, such sights give quite as great a degree of accuracy in aiming as the rifle is in fact capable of attaining. It is, however, surprising what good shooting can be made at a target even with rather coarse sights. For shooting in the field, the sights should not be liable to be injured at a touch, and the eye should have no difficulty in seeing the foresight at once, even in a bad light. Therefore it must be both distinct in colour, or rather in illumination, and large enough to be seen clearly while the eye is focussed upon the mark. It should show dark against a light

background, and light against a dark one. While bright in a gloomy light, it should not unduly catch the sun's rays. It would be impossible, unfortunately, to find any arrangement which would quite perfectly secure these results. The present writer thinks well of the foresight discs of white enamel which are now fitted to rifles, and generally of a white colour for the foresight. As regards the backsight, it is a matter of taste whether the notch be wide or narrow, deep or shallow, or be omitted, leaving a straight bar. The bright line to guide the eye to the true centre, which is a convenience with the V, becomes a necessity with the bar, and may well take the form of a triangle with its vertex touching the centre of the bar. The natural tendency in firing hurriedly is to take too much foresight, especially with a wedge-shaped sight with a fine tip, such as is the military "barleycorn" pattern. The tendency is to pull the trigger when the sights are aligned, without waiting to fine down the amount of sight taken so as to get the normal aim taken in deliberate shooting. Hence a chief advantage of the bead sight, the most conspicuous part of which is the tip.

It is bad to form the habit of taking a very fine sight. Good shooting can quite as well be made with a rather full sight, when once the

eye has become accustomed to it, and aim can be taken more quickly, and with less effort to the eye. A good system in using the V sight, is to have it of a moderate size, and to bring the tip of the foresight level with the shoulders of the V. This gives useful guidance in keeping the aim constant as regards elevation, and there is but little obscuration by the backsight of the surroundings of the point aimed at —a matter of special importance in a running shot. A small square notch in the backsight, large enough just to contain amply the bead of the foresight when aim is taken, also answers well. The writer thinks highly of sights on the principle of the Lewis sights, applied to the earliest issues of the Lee-Metford. These consist of a square notch in the backsight, and a square block with a white line or sawcut down the middle of it, for foresight. The latter is seen through the notch of the backsight, which it nearly fills, and the flat top of the foresight comes into line with that of the backsight. For picking up an aim in a hurry, without any tendency to shoot high, these sights are much superior to the ordinary barleycorn foresight used with either the V or the bar.

Men differ so much in the aim they take with the same sights that the purchaser of a

sporting rifle should, if possible, try it himself on the gunmaker's ground, where he can have the sights regulated to suit his own shooting. With the sighting which for one man gives the proper elevation at (say) 100 yards, another may find the same rifle throw every shot much above the bull's-eye, and *vice versâ*.

The Lyman-Beach sights, which consist of an aperture backsight fixed upon the grip of the rifle so as to be near the eye, and a fine bead foresight, are excellent for accuracy, and can well be used, if the conditions are not very unfavourable, in the field. There is with them some loss of light, which is sometimes a disadvantage, as when dusk is coming on, or in shooting at an object in deep shadow. But the field of vision is not otherwise obscured, and a good view is gained all round the foresight. The eye has no difficulty in centering itself to the backsight, and the attention can be given almost entirely to the position of the foresight with respect to the object aimed at. The backsight—and this is so far a drawback—has to be so near the eye as to make these sights unsuited to any rifle having a heavy recoil. It is raised on a pillar, which is hinged so as to fold down, and has a screw motion to vary the elevation. These sights, in fact, are an adaptation for sporting purposes, and *minus*

the more elaborate adjustments, of the fine sights used for target shooting with the match rifle.

Telescopic sights are very easy to aim with and very certain in use, but they are heavy and bulky, and require favourable conditions, being ill-suited for a hurried or a running shot. And they are comparatively easily put out of adjustment by a jerk or blow. The ordinary form of telescope, too, knocks against the eye in the recoil, which is inconvenient. But aim taken through a telescope gives a degree of confidence scarcely to be attained with other methods of sighting. The mark has merely to be brought into the field of the glass, the cross threads or aiming points placed upon the right spot (allowance being made for wind or for distance), and the trigger pulled. If the rifle is a good one, there is no uncertainty about the result. The telescope should not have at all a high magnifying power, as it is important not to reduce the size of the field too much, and nothing is gained by magnifying details unduly. Sometimes, as in waning daylight, an object can be defined with such sights well enough for a shot, when the mark is so indistinct as not to allow of a certain aim being taken with open sights. To aim with a rifle fitted with a telescopic sight is a striking object-

lesson in the impossibility of holding a really steady aim. There is no position, it soon becomes obvious, in which the rifle is free of all motion from the pulses. Every small movement becomes magnified to a surprising extent, even such movements as with open sights would be inappreciable. The larger "wobbles," due to the tension on the muscles, from which no man is free in the less steady positions, become really alarming when magnified, and it seems a miracle if one can let off anywhere near to the point aimed at. The consolation is, that what looks in aiming like a very wide shot, often proves on subsequent investigation to have been a very close one.

CHAPTER IV.

Of Powders in General.

Gunpowders in these days are many and various; indeed, it is only by courtesy that some of them can be called powders at all, for the form of powder, or dust, is not by any means the only one which modern explosives can assume. And to us, to whom the word "powder" in any military or sporting connection can only mean an explosive used to propel a projectile, the thought comes oddly enough that in the far-off dark ages, when the alchemist in his laboratory first compounded the "villainous" mixture of saltpetre and sulphur and charcoal, it was a mere terrifying, noise-making concoction, whose only conceivable use was to flash, and to smoke, and to boom, and so to strike terror into the mind of an ignorant foe. The invention by which the explosive was closely confined, and allowed to exert its power in one direction only, was certainly by many years, and apparently by many centuries,

younger than the discovery of the force which it controlled. Let us endeavour briefly to investigate something of the history of gunpowder.

Sad as it may be, and revolting to one's cherished prejudices, to discount the claims which tradition has raised and often reiterated on behalf of Schwartz and of Roger Bacon to be the discoverers of gunpowder, yet it must be admitted that a very little research leads to the conclusion that the knowledge of the deadly compound had its origin in yet earlier times. There is good reason, in fact, to think that the recipe for making it was already well enough known to be likely to be in the hands of the most learned and best read alchemists of the thirteenth century. W. Greener, in his book on "The Science of Gunnery" (1841), quotes from Roger Bacon's "Epistles of the Secrets of Arts," written, it would seem, in the year 1270, the following passage:—"Mix together saltpetre with *luru mone cap ubre* and sulphur, and you will make thunder and lightning if you know the mode of mixing." This sounds, as regards one of the ingredients, a most puzzling pronouncement, but more than a glimmer of light dawns upon the enigma when it is observed that the mysterious *luru mone cap ubre*, by mere transposition of letters, becomes *car-*

bonum pulvere, that is, charcoal. For though the anagram, which is here used for concealment of the phrase, is at best a childish puzzle in the eyes of modern men, it was one of the rather primitive, but doubtless effectual, devices adopted in the middle ages to conceal from the layman what he was not meant to know, and to maintain the halo of mystery and the prestige of secret power and exclusive knowledge which in those times surrounded the students of chemistry and natural philosophy. In the quotation given it will have been noticed at once that Bacon does not appear to have any idea of claiming the invention as his own. What other evidence have we, then, for thinking it to be yet more ancient than his time?

Light comes out of the East, and it may well be that the ancient continent, which has been the fruitful mother of so many mysteries and old inventions, in this case, too, set the feet of the Western nations upon a track new to them, and one that has led to developments of which Asia in thousands of years never dreamed. There is a curious reference given in an article on the subject of gunpowder, in a former edition of the "Encyclopædia Britannica," to the Life of Apollonius Tyaneus, by Philostratus. In this work it is stated that Alexander the Great, during his campaigns in the East, was unwilling

to attack the Oxydracæ, who dwelt between the Hyphasis and the Ganges, because they lived under the protection of the gods, and overthrew their enemies with thunder and lightning which they shot forth from their walls. This remarkable statement might be an ingenious and purely imaginary reason fabricated to account for the limit in one direction of Alexander's conquests; but it is much more likely that the story had some foundation in fact. The exact parallelism between the expression used by Bacon and that just quoted points very distinctly to the use of some explosive producing both sound and flash. The fact that artificial thunder and lightning are gravely accepted as a sufficient cause to stay the progress of so mighty a conqueror is a notable proof, if proof were needed, how great was the moral effect of such discharges upon an ignorant though very powerful enemy. Clearly, it was much greater than we of the nineteenth century can easily imagine, for, although we know something of the overwhelming terror and awe inspired by the first impression of firearms in savage tribes unacquainted with them, yet we attribute much of this effect to the thunderbolt destructiveness of the missiles, a feature which is rarely part of the first impression.

Colour is lent to the probability of the story

cited above by the consideration that gunpowder was undoubtedly known in China many hundreds of years, probably as much as 2,000 or 3,000, before the time at which it is first heard of in Europe. It would be only in the nature of things that such an invention should by slow stages work its way westward across Asia—and this would bear out the story about the Oxydracæ—and, crossing India, find its way at last to the shores of the Mediterranean. Fireworks were no doubt in ancient, as in modern China, one of the most effective, because most noisy, means of securing the attention of the object of worship, and of advertising to him, and incidentally to the human race in the neighbourhood, the piety and devotion of the worshipper. The inflammable compound known as Greek fire seems undoubtedly to have reached the Greeks from the East. The writer of the article already alluded to in the "Encyclopædia Britannica" states that gunpowder is described by an Arabic writer (in the Escurial collection, and translated by Casiri) in 1249, that is, prior to Bacon's description of it. The Eastern alchemists (is not the word alchemy itself Arabic?) were no doubt generally acquainted with the recipe for gunpowder; and since their lore and their writings formed the foundation for the researches of the European

alchemists, we are led to the conclusion that there was no independent discovery of gunpowder by Bacon, but that it was a piece of knowledge which he shared at least with the most advanced investigators of his day. And it is not long after his day that we find the first signs of the application of gunpowder to the projection of missiles.

A remarkable point in the history of gunpowder is the slow improvement in its manufacture and quality. The intimate mixture of the ingredients naturally puts it into the form of a very fine powder, which is known as "meal powder." In old days it was called Serpentine powder, and one William Bourne, writing on gunnery in 1587, draws the distinction between "Serpentine" and "Corne powder," the latter being the grained form which alone is familiar to us at the present day. Bourne praises the Corne powder as good, and he makes it clear that the other was more susceptible to damp and apt to cake. Indeed, at this time it clearly was losing favour, and later, in 1644, Sir Henry Manwayring, in his Seaman's Dictionary, mentions Serpentine powder with the note "This we never use at sea," and describes two sorts of Corne powder, viz., cannon powder, which he says is not very strong, and musket powder, which is of all powders "the finest,

strongest, and best we can get." In Bourne's time, gunpowder was commonly made, especially (he says) "by the Bours in Germanie." But it was irregular; its goodness had to be judged by its taste, its colour, and the rapidity with which it burned, and the quantity of the charge regulated in accordance with its quality. The Corne powder was stronger than the Serpentine, so much so that with it only two-thirds of the nominal charge were required. Bourne is advanced enough to advocate putting up the charge for the larger muzzle-loading guns in a "cartredge," the chief advantage of which evidently was that it reduced the danger of explosions on board ship. For he complains of the frequency of these because of the loose powder lying about and catching fire from the "linstockes and candels" which had to be kept alight. His book gives us a curious insight into the condition of things 300 years ago, and clearly shows what were the resources and appliances of gunnery with which Elizabeth's great sea-captains overthrew the concentrated power of Spain, when, by the favour of God and their own skill and prowess, they shattered the vast Armada, confident of victory.

Down to the middle of the present century the investigators of problems in gunnery experienced constant difficulty in obtaining

powder of good and even quality. Until it was made, as in quite modern times, in considerable quantities, and the different batches carefully blended, it was almost impossible to obtain trustworthy *data* for scientific purposes. Robins in 1742, having tried every kind he could get, says: "The common sale powder in England, such as is to be had at almost every grocer's, is much worse than the Government or battle powder, and extremely various according to the caprice of the maker. I have tried some whose strength has been in proportion to the Government powder as two to three nearly, and other parcels have been still worse, but the worst of all is the powder made for the African trade, usually styled Guinea powder." Both Count Rumford and Charles Hutton took great pains, and had much difficulty, in providing themselves for their researches with powder upon which they could rely, and for this purpose they used various forms of Eprouvette to test the strength of different batches. Even Sir Joseph Whitworth, when, forty years since, he began his great series of rifle experiments for the Government, is said to have had to use the siftings of cannon powder as furnishing the best powder then available for rifles.

For more than thirty years, however, there has been no difficulty in obtaining rifle powder

of even and consistent quality. Messrs. Curtis and Harvey's "No. 6" powder is probably the best known in this connection—a powder which for a very long time set the standard for our military powders, such as suited the Snider or the Martini-Henry. For many years batches have been produced by this firm of almost unvarying quality, and capable of giving the highest results for accuracy. It may, indeed, be said that the standard of excellence to which our leading English manufacturers have brought the various forms of black powder used for sporting purposes leaves nothing to be desired.

But the days of black powder are surely numbered. Slowly, but with a relentless certainty, the so-called "smokeless" powders are invading the ground in which for so many years it held undisputed supremacy. Schultze and E.C. and their newer rivals, all sharing the great advantage of substituting for a heavy cloud of smoke a thin vapour, and giving less kick and less dirt and fouling, now almost monopolise both game and trap-shooting with the shot gun. For the new type of small-calibre military and sporting rifle, of which the Lee-Metford is in this country the best known example, black powder is for several reasons distinctly unsuitable. There has now been

produced quite a crop of powders for arms of this class, of which it may be said that most have some good points, although none of them can be pronounced perfect in every respect. A successful invader very rarely fails to push his advantages to the uttermost, and there is good reason to think that the new explosives will eventually monopolise the pistol and the sporting rifle, as well as the shot gun, the military rifle, and the cannon. It may, however, be some time yet before black powder is entirely beaten out of these departments at home, while it certainly has advantages of simplicity—as in its capacity for ignition by the spark of a flint—which will long ensure its use in remote and uncivilised countries.

All powders, and not least those due to the inventiveness of the last few years, are susceptible, as regards the violence of their explosive force, to the variations of the temperature at which they are when fired. The force developed by a given weight of explosive is greater with a high than with a low thermometer. But it would only be in very exceptional circumstances that this effect could be great enough to be material at sporting distances.

We may conclude the present chapter with a word of advice as to the preservation of small-arms. The interior surface of a rifle

barrel, when it comes from the maker, should be—and usually is—in perfect order, the grooving smooth, and yet not brutally scrubbed away with emery to give it a polish, a process which leaves the surface uneven and wavy instead of "true." If the shooting qualities of the weapon are to remain unimpaired, the perfection of the surface must never be allowed to deteriorate. Scrupulous care in cleaning it and in never leaving it dirty a moment longer than necessary, is essential. If the grooving be deep and have sharp edges, the difficulty of thoroughly cleansing every atom of the bore from the fouling, which loves to lurk in any corner it can find, is much increased. This anyone can testify who has had to clean both a Martini-Henry and a Metford rifle of similar bore; the latter needs infinitely the less labour of the two. Nothing but fine soft tow, flannel, or swansdown calico should be used. The cleaning rod should be, where the size of the bore allows it, of wood, and in any case it should be straight, so as not to rub against the sides of the bore. It should also be wiped before being used, to make sure that there is no grit upon it. The barrel should be cleaned from the breech end, as a comparatively small amount of wear from the friction of the rod at the muzzle end will

seriously impair its accuracy. Special attention should be given to cleaning the chamber. The writer prefers generally, and more especially with black powder, to wash out the fouling by passing two or three times through the barrel a wad of tow, or a small square of some soft fabric, soaked in water or a strong solution of soda in wâter, and then wrung out. The barrel is then dried out thoroughly with fresh tow or flannel, which must be scrupulously dry, and next, when all traces of damp are entirely gone, oiled with vaseline or good Rangoon oil, the former for preference if it is to remain for some time unused. Cheap vegetable oils, such as salad oil and the cotton oil commonly sold as olive oil, usually contain a proportion of water, and have a fatal tendency to become rancid. In keeping either guns or rifles, as in other things, prevention is better than cure. It is not difficult to preserve the polish of the barrel if the owner is blessed with anything of a conscience in such matters; but if its surface be once dimmed by the slightest deposit of rust, the plague grows and grows, and unless prompt and drastic measures are taken by competent hands, the dreaded incurable "honeycombing" soon appears unmistakably, and all real accuracy is gone. A single cleaning, especially after a wetting, cannot be relied on

for more than a temporary effect, and too often that cleaning is delayed, and the weapon laid by dirty in the gunroom till the morning; also some keepers make a point of slurring over the cleaning, and doing it with as little trouble as possible. The rifle, then—and indeed these remarks apply equally to shot guns—should be cleaned at once after use; and if not to be used again the next day should be wiped out and oiled afresh before twenty-four hours have elapsed. If it is to be put away for any time it is well to repeat this process after about a week. If kept in a dry cupboard little attention will now be required beyond an occasional wiping-out every few weeks *ex abundanti cautela.* There is nothing to be gained by plugging the muzzle and breech, as some do to keep the air out; but it should be remembered that both damp and a free circulation of air carrying dust are great promoters of rust. With proper care there should be no difficulty in keeping a barrel as good as new for many years. It has been the writer's experience that the tendency to rust, which is thought to depend partly upon the residuum from the fulminate of the cap, is much greater with black powder than with some of the smokeless powders, like Schultze, used in the "scatter-gun," which apparently leave a neutral deposit. On

the other hand, the fouling of some of the smokeless powders now used in rifles, while it is in some cases very difficult indeed to remove it thoroughly, also seems to attack the metal rapidly, and to have a very deplorable tendency to set up rust. With these, accordingly, very special care is required, and very prompt attention. The writer has known a considerable number of cases in which small-bore barrels of the modern military type have been rendered quite useless from rust after an amount of cleaning which would with black powder have been very sufficient.

CHAPTER V.

Of Smokeless Powders.

It was natural enough that as soon as the method of producing gun-cotton had been discovered, in the middle of the present century, the minds of inventors should have been attracted by the idea that it might be possible to produce some explosive on the same lines, but of a modified and controlled nature, which would be serviceable for use in firearms. It was obvious that a great improvement would be effected if gunpowder could be superseded by some other substance which would produce equal effects, and both weigh less and be less bulky, and also leave but little fouling or deposit in the barrel. Many attempts were soon made, especially in Austria, to solve the problem thus presented, but it long seemed as if the difficulties were insuperable. It was solved however at last, in one department, by the invention of nitro-powders suitable to the shot-gun; and their success paved the way for

rifle and artillery powders made on similar lines, for the conditions to be fulfilled were in these cases nearly analogous. The French, who in this matter seem to have given a lead to the rest of Europe, adopted, in 1885, smokeless powder in their ammunition for the Lebel rifle. This powder was known by the name of "Vielle" or "Poudre B," and there is some reason to think that the adoption of it for Service purposes was not successfully accomplished without several considerable and expensive failures.

From the moment when one European nation had taken this step it became imperative for the others to follow suit with what speed they might, even while the pros and cons of the application of smokeless powders to war were still under discussion. But it soon became obvious that the advantages—*cœteris paribus*—must be all on the side of what our accurate German cousins call "smoke-feeble" powders. Whether at sea or on land, the pall of smoke which overhangs the battle has always tended to check continuous fire, and to hamper communication and tactical movements. Those whose fortune it has been to stand on the deck of a man-of-war while at gun practice, when volumes of smoke from her weapons of all calibres, and more especially from the bigger guns, drift slowly with the ship, and for minutes

at a time envelop her from stem to stern with a murky, suffocating cloak, only to be compared with a London November fog of superior brand, well know how many precious moments might have to be wasted in which the maintenance of a continued fire might be of vital influence upon the issue of the fight.

To compare great things with small, the same trouble attends the sportsman when, on a still day, the smoke of his first barrel hangs and prevents him from being able to put in an effective second. We need not here go into the military question how far the screen of smoke may be advantageous for purposes of concealment, or how far it is an effective advertisement of the precise spot from which infantry or artillery fire is proceeding. One thing is quite clear, that the increased demand for rapidity of fire could not possibly be met with the old black powder, since it is now indispensable to maintain a clear field of vision while an unceasing hail of bullets is vomited from quick-firers, machine guns, and magazine rifles in a fashion undreamt of by our forefathers. It must be left to those who have practical experience of shooting dangerous game to say how the new powders will compare with the old for their purposes. Certainly one has read of a buffalo or elephant in jungle charging at

the smoke of a shot just fired. On the other hand, the writer has in his mind a remarkable incident which happened only a year ago to a friend of his (who is second to none in his skill with the sporting rifle) while stalking in Scotland. He was using a modern magazine rifle of small calibre, and firing a smokeless powder. With this weapon (it was actually the ·256 Mannlicher, Roumanian pattern) he had had great success in stalking, and on the occasion in question was trying a bullet slightly differing in pattern from those which he had been using. He approached within about 130 yards of a good beast and deliberately fired his shot. No result. The stag stood still, raised his head, and looked about him vaguely in a puzzled fashion. He fired again; the same thing happened. The stalker remarked that it was very odd, and that he had not seen the bullet strike. Indeed, had it struck anywhere near the stag it must have startled him, and set him going. Five shots were thus fired and the magazine of the rifle emptied. Then the stag moved a little lower down, and stood again. Three or four more shots were fired without the stag being hit or discovering where the sound came from. The echoes were puzzling, and doubtless he thought it was some new kind of thunder. It turned out afterwards that the

bullets were breaking up on leaving the rifle, and did not go anywhere near the animal. They had the steel thimble which encloses them slit longitudinally in four places, and also filed away at the point so as to expose the lead. They were thus too much weakened to hold together under the pressure and stress of being expelled from the rifle. Now, how many shots could have been fired with black powder and no bullet without the stag taking to his heels? Even if the echoes were confusing, the smoke must have shown the direction of the danger, and given him the alarm after two or three shots at least.

There is one undeniable benefit attending upon the use of the new powders. Their weight and bulk being smaller than that of black powder, gives an important advantage (for example) in the storage and handling of cannon charges. And this advantage extends in its degree to smaller weapons. Whatever allows of a reduction in the weight and bulk of the ammunition carried by the soldier or the sportsman is to be welcomed. It is well known that there are only 31 grs. of cordite in the ·303 cartridge, while that of the Martini-Henry contains 85 grs. of black powder. Yet the propulsive power of the latter is no greater than that of the former. True, the whole

amount of the weight of the powder is small, but the same cannot be said in comparing the bulk of the cartridges.

We seem here to have clear indication of a change which appears as if it were inevitable in the near future. Why should we carry about ammunition unnecessarily bulky for sporting purposes? By the use of concentrated powders, of which ballistite and cannonite are an example, we can diminish considerably the length of the cartridge for either the rifle or the shot gun, without in any way diminishing the efficiency of the charge. It would certainly be an advantage to reduce the length of a 12-bore cartridge by half an inch; loading and extraction would be easier, and a material saving effected in the space occupied by ammunition. Why should we have to fill up (as is now done for such powders) the superfluous room in the base of the cartridge, when we might simply abolish it? And why should we have long and bulky bottle-shaped express cartridges if we can shorten their length considerably and have no thicker a body to the cartridge than the size of the bullet makes necessary? Then there have been a number of accidents to guns and rifles in the last few years from the charge of concentrated powder being loaded by measure as if it had been black powder. Any

change which would make this impossible, by reducing the capacity of the cartridge, would make a great addition to the sportsman's safety.

The smokeless explosives of the present day (they will probably always continue to be called powders, although for many of them this name, in its literal meaning, is entirely out of place) may be divided into two classes, in accordance with their composition. First we will put the class containing both nitrated cotton or other fibre, and nitro-glycerine, of which cordite is in this country the best known example; and second, those whose basis is nitro-cotton or fibre, but which contain no nitro-glycerine. Both explosives just mentioned are among the most violent known. Glycerine, when treated with a mixture of nitric and sulphuric acids (and it may very easily explode in the process) becomes nitro-glycerine, a substance liable to explode on concussion, or, if frozen, almost at a touch. It has been a favourite compound of Fenian extremists, Nihilists and Anarchists, and is the basis of blasting gelatine and dynamite. Gun-cotton is finely-shredded cotton fibre treated on the same principle with nitric and sulphuric acids, and is the explosive used by the Royal Engineers. It would hardly have been supposed that an intimate mixture of nitro-glycerine with very finely divided gun-

cotton would have produced anything but a very violent explosive. Yet quite the contrary was found to be the case by Nobel and by Maxim, and the Service explosive—cordite—is merely an adaptation of this discovery. It consists of 58 per cent. of nitro-glycerine, 37 per cent. of gun-cotton, and 5 per cent. of a mineral jelly, vaseline. This explosive, while it is said to have great stability, and to be proof against changes of temperature and the lapse of time, certainly is of a very mild nature when not ignited by fulminate. The form in which it is made is that of cords of diameters to suit the weapons for which it is intended, varying from large ropes of perhaps 3 inches in diameter for the biggest guns, to fine strings like thin catgut for the Lee-Metford. There are sixty strings of cordite, each about 2¼ inches long, lying lengthwise in every Lee-Metford cartridge, and if one of these be taken in the fingers, and a light applied to its end, it will burn quite gradually, and may even be blown out. In 1890, experiments were officially made to determine the liability of cordite to explode when in bulk. The account of the trials, given in the report for 1890 of H.M. Inspectors of Explosives, is curious and instructive. Four separate times was the experiment made of letting off 100 lbs. of cordite fastened in a large and strong

wooden box. "Coarse" cordite, 3 inches in diameter, was first tried, and it was found that a tube and small priming charge of gun-cotton would not ignite it. When lit by means of a small priming charge of fine cordite (·05 inch in diameter), the whole mass burst immediately into flame, and burned with great rapidity and brilliancy for about three seconds. On a repetition of the experiment it burned similarly for about seven and a half seconds. But the box was in neither case broken up; only the lid was forced off. Then was tried a similar experiment with 100 lbs., first of coarse, and then of fine cordite, ignited by the box in which it was placed being surrounded by wood and shavings, which were set on fire. The coarse cordite ignited in fifteen minutes, and the fine in half that time; the former blazed for four or five seconds, and the latter went off with a sort of mild explosion, but only forced off one side of the box. Then six boxes, containing 100 lbs. of coarse cordite each, were placed together, five on end and one on the top. The cordite in the centre box of the lower ones was set fire to, and burned for about six seconds; but it did not throw off the top box, and no other box caught fire. Next, the five uninjured boxes were put in a heap and a bonfire lit around them; after a quarter

of an hour one caught fire and blazed, and the others followed suit at intervals of a few seconds. A very similar result attended a final experiment on the same lines with six boxes of 75 lbs. each. The cordite in each box ignited quite independently, and merely burned without explosion.

These results are interesting as showing the sluggish nature of the compound formed by the union of two very violent explosives. It is perfectly well known to ammunition-makers that the ordinary cap used for black powder is too quick to ignite cordite at all, and, indeed, some of the other smokeless powders seem to be equally slow. It is obvious, then, that cordite is not nearly so dangerous an explosive to deal with in bulk as ordinary gunpowder, although it is beyond doubt that in the factories its constituents, nitro-glycerine and gun-cotton, may, before they have been combined, continue to be occasionally a source of dangerous and deplorable explosions. There are other nitro-powders of very similar composition to cordite; Nobel's ballistite, used by Italy for small-arm ammunition, is almost identical with it, while Mr. Maxim's powder, and the Leonard and Peyton powders, made in America, also contain nitro-glycerine.

The power of endurance shown by any ex-

plosive is a most important point when any question arises of its adoption for the British naval or military service, and equally so from the point of view of the British sportsman. The most rigorous cold of Canada, and long hours of exposure to an Indian sun, must leave it practically unaffected, while the presence or absence of moisture must be almost immaterial to its behaviour. For cordite it is claimed that it has emerged triumphant from exhaustive official trials under many conditions, and that its stability is entirely to be relied on. How far it may be superior in these respects to other powders, and especially to those containing no nitro-glycerine, we have no official information. The American trials would seem to point to a slight superiority in the stability of the nitro-glycerine powders. It is, however, noteworthy that the majority of the European nations seem to be quite satisfied with the nitro-cotton powders which they have adopted, although it must be allowed that their requirements are, from the nature of the case, by no means so difficult to satisfy as those of the Empire on which the sun never sets.

The rifle-powders made of a controlled nitro-cotton, without nitro-glycerine, are many, and the majority of them can hardly be said to have emerged from the experimental stage. The

best known, perhaps, of those for modern small-bore rifles is rifleite, which has a good reputation well established. It has been used and given satisfaction in various parts of the globe, and seems to be particularly well adapted to the Maxim machine gun. There are not many other powders of the kind of English make, but special mention must here be made of cannonite, a powder which, although not in every point perfect, has a good record for high scores at Bisley, and is, so far as the writer knows, the only smokeless powder which has been successfully used at the long ranges at Bisley, in public competition against black-powder ammunition, in match rifles of about ·450 bore—the calibre of the ordinary Express rifle. At the meeting of the National Rifle Association, held in July, 1895, several good prizes in the "Any-Rifle" competitions at long ranges were taken with ammunition loaded with this powder, the most noteworthy, perhaps, being the Any-Rifle Association Cup, open to all comers, and won by Mr. Henry Whitehead, who alone succeeded in placing not only all his ten competition shots, but also all his three tie-shots, at 900 yards, within the magic circle bounding the three-feet bull's-eye. This is proof enough of the regularity of ignition which can be attained in powders of this

kind, in spite of the fact that they seem to be especially sensitive to irregularities in the quantity or ingredients of the composition in the cap or "primer." That there is a field for the increased use of smokeless powder in sporting rifles of various calibres hardly admits of a doubt. Among the better known of the foreign nitro-cotton or nitro-cellulose powders are Walsrode, Troisdorf, and Normal powders, which have not yet made good any claim to superiority over the English powders.

The ideal smokeless rifle powder, in fact, yet remains to be produced, although at present we have several in quite a practicable stage. There are points which present themselves to those who deal with, or use, ammunition which are apt to escape the notice of the chemist who compounds the explosive. And there would seem to be no existing powder which perfectly fulfils all the required conditions. For instance, it is important that it should be in a form easy to measure within a very close degree of accuracy. In a charge of 30 to 40 grains of one of the new powders there is in general fully double the propulsive power of the same quantity of black powder, and the effect of an error of a certain amount in the weight of the charge is proportionately larger with the smaller quantity. Some of the powders, which take the

form of thin square grains with a tendency to hang together, and to "bridge" in pouring, do not seem so well adapted for loading by measure as those of finer and less flat grain. The device of squeezing cordite and ballistite into strings and cutting off a certain length for each charge, is one which has met with considerable success. A very great regularity is obtained by the substitution in this way (with special machinery) of linear for cubic measure, and the results are as even as the best of measuring instruments will give with grained powder. The strings also are very easily inserted into the cartridge cases and do not spill. On the other hand, the present writer is not satisfied that the regularity of ignition is so good with this form of powder as with the granular form.

Other points in which the ideal powder should excel are such as regularity in the size of the grain, regularity in the velocity given by similar charges, moderation (not necessarily lowness) of pressure. Then the residuum left in the barrel should be of such a nature as to facilitate the passage of the next bullet, and to be very easily removed. Cordite, for instance—and it is not the only sinner in this respect—leaves a fouling almost impossible to be cleaned out except by extreme measures,

if the barrel has been left unclean for even a few hours. It is to be feared that Tommy Atkins has discovered to his cost the great difficulty of keeping his rifle barrel in good order. A chemist connected with the production of a foreign powder is said to have gravely recommended dilute sulphuric acid as the best means of removing the fouling of the powder in question! It would have been difficult to give a better recipe for destroying the surface of the bore. And even when the fouling does not refuse to be stirred, it would seem in many cases to have a great tendency to set up rust. From this weakness the ideal powder should be free. But at present it would seem that there is hardly one of the smokeless powders used in the modern small-calibre rifle which does not leave a deleterious deposit in the barrel. Here certainly there is much room for improvement. Experiments made for the United States War Department go to show that the effect upon steel of the residuum of nitro-cellulose powder is decidedly greater than that of nitro-glycerine powders, when both are flashed off on a steel surface in the open air. This, however, cannot be considered a conclusive test as regards the effect of the residue when the explosive is burnt in the barrel under high pressure.

There remains one defect of the powders

containing nitro-glycerine which it is most desirable to avoid. Erosion of the surface of the bore seems to be, in a greater or less degree, the inevitable concomitant of all smokeless powder in the small-calibre rifles; but cordite, and no doubt also the other powders which contain nitro-glycerine, are many times more destructive in this respect than the nitro-cellulose powders. It would seem that the heat which they develope in combustion is so enormous as positively to melt the surface of the steel, and to vaporise a minute portion of it at every shot. Certain it is that a very few score rounds of cordite leave unmistakable signs of damage in the ·303 Metford barrel, and that a few hundreds will so injure it that it can no longer be depended on when real accuracy is required. This is a serious draw-back, and one which seems extremely difficult to overcome. It can hardly fail, too, to have one lamentable effect—that of tending to put a limit upon the number of rounds which the soldier or volunteer can be allowed to fire in practice in the course of the year, and so to reduce both the interest taken in marksmanship and the standard of skill—a deplorable prospect, and one which it is to be hoped will never be realised.

CHAPTER VI.

OF THE SPIN OF THE BULLET.

WONDERFUL as it is that a projectile, large or small, should be so far under control as to be compelled to keep a perfectly consistent course during a long flight, while it battles with an enormous resistance—that of the air—the oldest and simplest analogy, the simile of a spinning-top, is perhaps the best that can be made use of to illustrate its motion. Very mysteriously does the action of the centrifugal force developed in the body of the top serve first to bring it into equilibrium on the point upon which it turns, and then to maintain it upright, and apparently motionless, for a while. At last the double friction, that of the surface of the top against the air and of its point against the ground, so diminishes its speed of spin that, after swaying round and round, it at last falls and rolls away in its dying struggles. The gyroscope, in which the top is pivoted so as to spin in a ring, and while it spins keeps the ring

balanced upon a point, shows in an even more remarkable way the strong resistance made by a body spinning at a high velocity to any change in the direction of its axis. This principle was applied by Professor Piazzi Smith to providing a telescope, for use at sea, with a mounting which should remain steady and maintain its position independently of any motion of the vessel, and quite lately it has been brought into use to give a steady platform for the electric searchlight on board ship. It is this same force (to compare small things with great) which preserves the plane of the earth's motion round the sun, and keeps the direction of its axis (but for certain effects of the attraction of the sun, moon, and planets) constant.

To discharge a projectile into the air, and at the same time to give it, round its axis lying in the direction of its flight, a spin sufficient to coerce it into keeping a steady course, is the particular virtue of the spirally-grooved barrel. No means so simple or so sure for accomplishing this end has ever yet been invented, nor, we may suppose, ever will be. Devices for spinning the bullet in other ways have over and over again been tried, and in many cases it would seem as if special pains had been taken to find a troublesome method of doing it—and

then doing it ineffectually. One ingenious inventor proposed that the projectile should be made hollow, and fitted over the outside of the barrel, which was to be rifled *externally*. Another wished to make the projectile somewhat in the shape of a quoit or a disc, and to give the same kind of spin as is given to a flat stone in throwing "ducks and drakes." Far more reasonable was the idea of a third, that there might be fitted into the breech of a muzzle-loader a small, square pillar, slightly twisted, over which a square hole in the bullet might fit, and which would serve to give it rotation.

A more modern suggestion for spinning the bullet deserves mention, if only as a notable example of the process of putting the cart before the horse; for it really seems to have been made seriously, though it is hard to believe it. This is the ingenious notion that the shoulder-gun or cannon should be a smooth bore, and that the whole barrel should be rotated upon a longitudinal axis, so that, when the charge is fired, the projectile should leave the muzzle with a rate of spin corresponding to that now imparted to it by the grooving. On a first glance, the idea may seem to have something of plausibility. But consider what speed of rotation is required. Could anyone hope to impart a velocity of rotation of from

120,000 to 180,000 turns per minute to the barrel of a magazine rifle, without adding to it so much weight of machinery as quite to destroy its portability? Think, too, of the complications and difficulties in obtaining a rapid rate of fire or an accurate aim from such a weapon! Nor is the idea more practicable for larger weapons of less mobility. Imagine the apparatus and motive power necessary to spin a gun weighing from 5 to 50 tons at a speed of many hundred revolutions per minute, part of the problem being that the facilities for loading and directing it must be retained! And in exchange for these difficulties, what would be the advantage? Merely that the grooves cut in the barrel would be dispensed with, and that some quite small benefit—probably hardly appreciable—might be gained in the closer fitting of the projectile to the bore!

But the favourite device of perverse ingenuity—as the records of the Patent Office attest—has been to attach to the bullet some form of metallic feathering by which the resistance of the air might be made to give the rotation. The nearest approach to solving the problem satisfactorily on these lines was made some fifteen years ago by Dr. Macleod, who succeeded in producing a flat-headed bullet, which could be fired with some accuracy

from a smooth-bore barrel. The rotation was imparted by four tapered holes running the length of the bullet, and spirally inclined to its longer axis. This bullet gave good results in a 12-bore gun up to 100 yards, but not further. The radical defect of all such systems is that the speed of spin which the air can be made to give is insufficient to maintain accuracy during a long flight. In the last few years the need for a gun which will fire shot in the usual way, and can also be depended on to make accurate shooting with ball at fair sporting distances, has been met by the invention of guns which are smooth-bores with a couple of inches of rifling in the muzzle end of the barrel (such as the well-known "Paradox"), or have a very slight grooving running the whole length of the barrel.

The proper slant or pitch for the grooving, on which the rate of spin of the ball must depend, was long a ground of contention. Early in the century there was much difference of opinion as to whether a whole, a half, or a quarter turn in the length of the barrel was the most satisfactory. In old days the slighter turn was in general favour for shooting, and was also found to be less troublesome in loading from the muzzle. But the author of "Scloppetaria" in 1808 declared himself in

favour of a more rapid spiral than that in common use, as giving better results at distances beyond 100 or 150 yards than the other. He maintained, however, curiously enough, that the spin is imparted to the ball not by any motion that it receives from the grooving, but by the pressure of the air during its flight upon the spiral indentations impressed upon it before it left the barrel. This elementary fallacy a very little experiment would have dissipated.

What, then, are the considerations which determine the proper amount of rotation to be given to the bullet? It must be enough to carry the bullet safely over the critical point at which it clears the muzzle and receives the full effect of the pent-up gases which were behind it urging it up the barrel, and which, as soon as it is freed, rush around and past it with a velocity many times greater than its own. If a long bullet be fired from a smooth-bore, this rush of gases turns it at once head-over-heels, as anyone knows who has tried the experiment. The writer remembers trying it when at school with a toy cannon, and being astonished to find that the bullet not only struck the door of the room (at which it had been directed) sideways, but penetrated it and buried itself in the panelling on the other side

of the passage outside, whereby the legs (for the shot was luckily aimed low) of a boy passing by were put for an instant in much jeopardy. In some experiments for penetration with modern military rifles, in which it was desired to simulate the striking effects of bullets at long ranges by firing them with reduced charges, it was found that with a less muzzle velocity than about 1,000 ft. per second (the velocity of the full charge being about 2,000 ft.) the spin was not enough to prevent the bullet from being turned over as it left the muzzle. So great, indeed, is the blast of the gases upon the bullet, that there is good reason to think that its speed is slightly increased by the parting "kick" which it thus receives after it has actually left the rifle.

The spin which is enough to start a bullet well on its course—not with a "wobbly" motion, but steadily like a top when "asleep"—is enough to maintain its steadiness of flight for all practical ranges. But it must be remembered that the speed of spin depends quite as much upon the velocity of the bullet as upon the rate of spiral. Thus, in the case of the old Enfield rifle, which gives a velocity of 1,300 feet per second, and has grooving of such a pitch as to make one complete turn in 6 feet 6 inches, the bullet spun 200 times

in each second. The experiments of Sir Joseph Whitworth showed that with a proportionately longer projectile a more rapid rate of spin was needed to ensure steadiness. He tried many different pitches of spiral, and relates with satisfaction how he once penetrated seven inches of elm with a hardened six-sided bullet, fitting a barrel of ·45-in. bore rifled with *one turn in each inch* of its length. As a result mainly of his experiments, the bore of the Martini-Henry was fixed at ·45 in., and its pitch of rifling at one turn in 22 in. This, with a muzzle velocity of 1,300 ft. per second, gives a rate of spin of 714 turns in one second. But we move faster in these days, and the Lee-Metford rifle, ·303 bore, with 2,000 ft. muzzle velocity, spins its bullet no fewer than 2,400 times in each second, while the latest foreign magazine rifle of ·256 bore gives a spin of a good deal more than 3,000 times a second, a figure which sounds almost incredible.

It may well be asked, how is it possible to give so very rapid a spin without straining the bullet and tearing it to pieces? The answer is, that the pitch of the grooving is very little more in the Lee-Metford with its one turn in 10 in. than it is in the "match rifle" of ·461 calibre which is rifled with one turn in

$16\frac{1}{2}$ in., and that there is practically no greater strain on the bullet while it follows the grooves in the one than in the other. The explanation of this apparent parodox lies in the fact that the pitch of the spiral merely effects a diversion of the surface of the bullet at a certain angle from the straight course which it would naturally pursue in the barrel as it moves forward. It is, therefore, proportional to the calibre, and one turn in thirty-three calibres or 10 in. in the Lee-Metford represents an angular value but little in excess of that which obtains in the "match rifle." The spiral of the 110-ton gun bears just about the same proportion to its calibre. It is to be observed that in flying through the air the ball is very much retarded, and very quickly loses its velocity, but that the speed of spin is much less quickly lost. It has been found that bullets which started from a barrel grooved with one turn in $16\frac{1}{2}$ in. were still, after a flight of 2,000 yards, during which most of their velocity had been lost, spinning fast enough to make one turn in every 6 inches of progressive flight, as shown by the marks impressed on them by a wooden target through which they passed.

It was one of the early theories that the apparent advantage in range which a rifle has over a smooth-bore was due to the bullet by its

spinning more easily boring its way through the air. Even at the present day the great power of penetration possessed by modern rifles is sometimes ignorantly attributed to the same imaginary cause. The confused analogy with a boring tool is of course quite fallacious. A bullet has no cutting edges, and, even if it had, it turns but once in several inches of flight, which would not avail much when, for instance, it punches a hole in a quarter-inch plate of hardened steel.

The round ball of old days had so little bearing on the grooving that any attempt to give a high rate of spin was apt to lead to the ball "stripping," or being driven over the grooves instead of along them. Soft lead and deep grooving were consequently accepted as necessities. On the introduction of the long bullet with a hollow base, which it was found could be expanded into the rifling by the sharp blow of the exploding powder behind it, it remained a general principle that the lead ought to be pure and soft to assist this process, the grooves being still comparatively deep. For it is one of the first essentials in a rifle that the bullet should fill the bore entirely as it passes up it, so that there may be no leakage whatever of the powder gases past it. It was Mr. Metford who discovered that this result could

be obtained with much more ease and certainty by using a bullet of hardened lead, and keeping the grooves quite shallow; and his method, which had other advantages, such as that of reducing the friction in the barrel, brought about a revolution in the practice of rifle-makers. He proved by experiment that the bullet, if made slightly smaller than the bore, was expanded into the grooving, so as completely to fill it before it had been moved more than a small fraction of an inch. He proved, too, that the bullet required only a much smaller hollow in the base than was then supposed to be necessary. It was he who designed the Pritchett bullet, in which this principle was applied, and which marked a step in advance in the year 1852. Mr. Pritchett acknowledged to Mr. Metford, but it would seem only privately, that he was indebted to him for the design of this bullet, but the name of its real inventor has never been publicly connected with it. Mr. Metford also found that it was possible for experimental purposes to give a proper spin to a bullet with rifling only one-thousandth of an inch deep; and pointed out that Sir Joseph Whitworth's system of fitting a six-sided bullet into a six-sided barrel necessitated rifling enough to spin a six-pounder shot. The lower part of the hardened bullet

was wrapped in a jacket of thin paper to prevent the lead from being rubbed upon the bore, and it was found that no lubrication was necessary.

In powerful military and sporting rifles of the very small bores now in use, such as the Lee-Metford — beside which the well-known ·380 rook rifle seems a big bore—the principle of having a hardened surface to the bullet is carried still further. So great is the stress, and so high the speed, that the friction becomes too heavy if a bullet of the ordinary hardened lead is driven through the barrel, and it is partially melted. A compound bullet is therefore used, having a leaden core encased in a thimble of some harder material, such as copper, nickel, or even steel. But as the bullet thus stiffened cannot well be expanded into the grooving, it is made in the first place rather larger than the bore, and is forced into it under very heavy pressure from the powder.

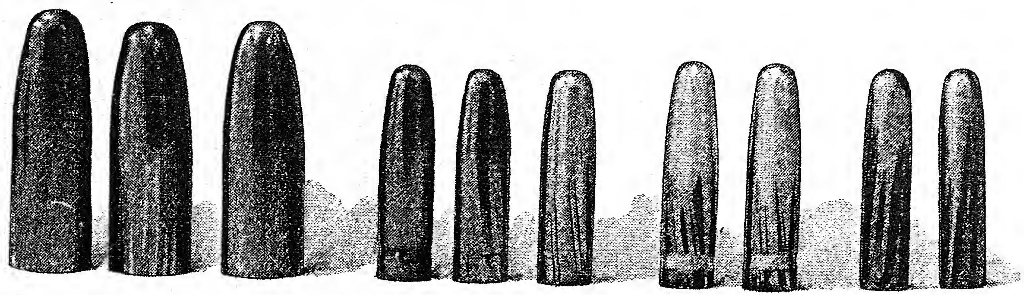
The form of the grooving is of much importance, especially when the old black powder is used. To obtain the best results it is essential that each bullet as it passes up the barrel should sweep before it all the residuum of fouling left by the previous shot, so that there may never be any accumulation of it. This result can only be obtained if the grooving is fairly shal-

low and free from sharp corners where the dirt may lurk, and which the bullet cannot thoroughly command. In this respect some methods of rifling (such, for instance, as the Henry) are sadly unscientific. With modern smokeless powders, on the other hand, it would seem to matter less what the precise form of grooving is, because the deposit of fouling which they leave is very slight. The depth of rifling in the barrel of the Lee-Metford is ·004 in. or a little more, but ·003 in. is quite as much as is really necessary in this class of rifle. The Metford segmental groove has been recently discarded in the Service Magazine rifle, and a grooving with square corners substituted, because this is found to be less easily obliterated by erosion.

We need hardly pause here to touch upon the theory of the "increasing spiral" in rifling. It is well recognised that in the first few inches of its progress up the barrel, the bullet, starting from rest, acquires speed in the first instants of its advance more rapidly than when it has been longer (we are dealing with very minute quantities) under the influence of the propulsive force. It is evidently reasonable that the rate of spin given to the bullet while yet in the barrel and advancing at a pace which is not uniform, should be uniform not in dis-

tance—not, that is, in accordance with each unit of length of the barrel which it traverses—but in time. That is, it is proper that the inclination of twist should be given to the bullet gradually as its speed is gradually increased, so that in each unit of time, as it advances, it should be inclined by a uniform increase of angle from its original straight course until the desired maximum of inclination is reached just as it arrives at the muzzle.

This is the principle upon which Mr. Metford's system of increasing spiral, the only scientific one, is based; and if the increasing spiral has not met with general adoption, it is because it is less well adapted for projectiles of proportionately great length than for the shorter ones, and because certain processes of repair and repolishing of the barrel are simpler with the uniform spiral in dealing with arms in quantity. The theoretical advantages of the increasing spiral are undeniable, although actually they are not found to confer any very noticeable benefits except when lead bullets wrapped in a paper patch are used. In this case the increasing spiral forces the bullet to shed its paper covering, which with the uniform one it does not invariably do, and so removes one element of possible aberration in flight.



PHOTOGRAPH OF RIFLE BULLETS.

SHOWING THE RIFLING MARKS.

The bullets are shown full size.

The plate appended to the present chapter represents a series of bullets, shown of their full size, from modern rifles. The larger ones on the left of the picture are copper-coated bullets fired from a ·461 Gibbs match rifle—precisely the same rifle which, mounted in the "sporting" form, has achieved such great feats in the hands of Mr. Selous. The tallest bullet, on the left of the picture, weighs 570 grs., the other two 540 grs. One of the bullets is unfired; on the other two the marks of the rifling may be seen in the shape of faint lines, nearly vertical, but inclining to the right towards the "shoulder" of the bullet. The wide, shallow grooves in rifles of this comparatively large calibre render the marks of the 7-groove Metford rifling less conspicuous in these than in some of the smaller bullets. The next five bullets are those of the Lee-Metford ·303 rifle. On all of them the mark of the "cannelure," or shallow groove, round the bullet above the base can easily be seen. The first three, two fired and one unfired, are bullets weighing only 200 grs.; of these three the two on the left are copper-clads, and the third, that on the right, which is lighter in tone, has a sheath of cupro-nickel. The two remaining of these five bullets are specimens of the service bullet, fired with cordite; this bullet has a cupro-nickel envelope,

and is of 215 grs. weight. The "Tweedie" and other sporting bullets for the ·303 are very similar to those shown here. It will be noticed that the marks of the Metford rifling incline to the left in all these ·303 bullets, the reason being that the rifling in the Lee-Metford is cut on a left-handed spiral instead of a right-handed one.

The two bullets on the right of the plate are samples of the steel-clad projectile of the Mannlicher rifle of ·256 bore. Their weight is only 156 grains, scarcely more than three-fourths of that of our service bullet shown alongside of them. Yet there is no doubt that this very small calibre makes a most effective rifle for military and, within limits, for sporting purposes. Whereof more in a future chapter. The rifling on these bullets shows that there are only four grooves, and that they are deeply cut—deeper, in fact, than is necessary—while, the rifling marks extend much nearer to the nose of the bullet than is either elegant or useful.

CHAPTER VII.

Of the Bullet's Flight.

It is very puzzling to those who have not had great experience in such matters to find how wonderfully easy it is in the field to put a bullet either too high or too low to hit the object aimed at. Where the distance is precisely known and is a familiar one, as is commonly the case in firing at a target, there is very little difficulty in putting the bullet on the right place. But as soon as we come to dealing with estimated distances, and especially when they are at all long ones, there seems sometimes to be almost a fatality working against us, and too often failure takes the place of success, and despair that of hope. Accuracy of weapon and of aim seem to be thrown away, and even previous experience to be of comparatively little use. With powerful sporting rifles, indeed, there is not very much difficulty so long as 100 to 120 yards is the furthest distance to be considered; but at somewhat longer ranges, while

yet the speed and weight of the bullet make it amply effective to kill, it is evident that the necessary increase of elevation on the sights is considerable, and at the same time most difficult to estimate rightly. With small rook rifles and old-fashioned weapons projecting the bullet with only a small velocity, the same difficulty becomes prominent at much shorter ranges, and it requires great knowledge and skill to make effective shooting at distances exceeding 50 yards. An example of this has been given in an earlier chapter of the present book. So noticeable is this apparently sudden deflection of the bullet after the first impulse (as it naturally seems) of the explosion is exhausted, that we can hardly wonder at the ingenious theories which in early times were invented to account for it. Before the laws of gravity were well understood, it was natural enough that even an experienced gunner such as was William Bourne should lay down (as he did in 1587) that the flight of a shot begins by "a Right line, so long as the shot goeth violently." He further goes on to deal with the remainder of its flight, and sets forth how the next part is an upward curve, and how then the shot goes along "the highest distance for a certayn space," and at last describes a descending curve until it reaches the earth again. "Point blanke," says

he, "is the direct fleeing of the shot without any descending from the mouth of the piece unto the mark." Here we see the early use of that unscientific and most fallacious term "point blank," which has continued in use nearly down to the present day, and has been the fruitful mother of many a false impression as to the flight of projectiles, and of many an argument and discussion as to its own precise meaning. So late as 1841, W. Greener, in his book treating of the science of gunnery, and presumably speaking with a particularly full professional knowledge, states that "Point blank distance is whatever distance the rifle will project a ball in a parallel line with the earth." In Mr. Walsh's book, "The Modern Sportsman's Gun and Rifle," published in 1884, the expression occurs, and is accompanied by an endeavour to give a definition of its meaning. But as the term is the name of a scientific fallacy, the only meaning that could be given to it would be some conventional one arrived at by general agreement, and no such agreement has ever been come to. We may be thankful that the term has now fallen into almost complete disuse, as the diffusion of scientific knowledge has advanced. Yet it dies hard, and the writer remembers seeing, within the last two or three years, a military rifle described as carrying point-blank up to 600 yards.

And yet it is long enough since the simple fact was known that any body free to fall and unsupported, whether in air or *in vacuo*, must immediately yield to the influence of gravity and instantly begin to fall; and that consequently the course of a bullet or shot must be a curve compounded of the forward motion given by the impulse and of the downward fall, and that this curved course commences from the very first instant at which the projectile is free of the muzzle. And because any falling body moves faster and faster downwards with each moment that passes, and at the same time the resistance of the air, eating up the velocity with which the shot was projected, makes its forward motion slower and slower, the curve must very rapidly become steeper and yet steeper, until, if free scope be given, the downward almost entirely predominates over the forward motion.

The conditions upon which the flight of a shot depends were understood by the most advanced scientific men at an early time, if we may judge by the utterances of the learned Italian mathematician Tartaglia. In his "Commentaries," written in the middle of the sixteenth century, of which an English translation by Cyprian Lucar appeared in 1588, he says that no pellet can range in a right line

except it be fired directly upwards or downwards, and adds, with the most perfect conciseness, "A piece will not shoot fifty paces, nor nor yet one pace, in a right line." The great Galileo, in his "Dialogues of Motion," printed in 1638, pointed out that the trajectory was a parabola except so far as it was affected by the resistance of the air, but he fell into an error which, in spite of Sir Isaac Newton's keener appreciation of the facts, long outlasted even him—that of considering that this qualifying factor amounted to so little as not materially to modify the shot's flight. Says Robert Anderson, using the quaint language of the time, in his book "To Hit a Mark" (1690): "Galileus tells us that the beginning of the Parabola will be deformed by reason of the Impulse of Fire; And the latter end by reason of the Resistance of the Air, which amounts to very little, saith he. Cavalierus bids us begin the Parabola where the force leaves the thing projected. And this line I call the line of Impulse of Fire, and take it for a right line for ease of calculation, although I believe the thing projected moves as it can so far as the Impulse of Fire or violent shake of the Engin is upon it, and the more irregular the thing projected is, the longer will be the line before it passeth into its Parabola." Truly, Master Anderson,

it was a wise pronouncement, and doubtless well-nigh as comforting as the old woman found "that blessed word Mesopotamia," to lay down as a scientific explanation that the projectile *moves as it can* in commencing its flight from culverin or catapult!

We may say, in fact, that the two great principles "C'est le premier pas qui coûte" and "Facilis descensus Averni" are both exemplified in the flight of the bullet. At first, while the velocity is at its highest, the resistance of the air is also most effective, but speed is lost much less quickly when the projectile has "slowed down" somewhat. Also, it drops at first so gradually that it can steal away (as it were) with an almost inappreciable amount of fall for the first few yards of its flight, while yet the projecting force has been diminished but little. Then the force of gravity pulls it down faster and faster, while at the same time it loses pace rapidly from the resistance of the air.

It will, perhaps, be interesting to investigate briefly the actual amounts of fall which obtain at different distances with modern sporting rifles. For this purpose we will borrow some figures from Mr. Walsh's useful book, which contains a careful record of a number of facts, and gives calculated results certainly close enough to the truth for our present purpose,

even though they may not in all cases be absolutely correct. From this book the figures in the annexed table are taken, so far as they concern the Express rifles and the Martini-Henry. The object of the table is to show the amount of the fall of the bullet at different sporting ranges with rifles such as are used for antelope, deer, and large game, and to enable comparison to be made between them. The assumption is that in each case the rifle is fired with the barrel in an absolutely horizontal position, and the figures show how far the shot will strike in each case vertically under a point level with the barrel.

Table showing the amount of fall of various bullets in a flight of 100, 200 *and* 300 *yards.*

A.—Express Rifles.

	Calibre of rifle. in.	Weight of bullet in grains.	Muzzle Velocity ft. in secs.	Fall at 100 yds. in.	Fall at 200 yds. ft. in.	Fall at 300 yds. ft. in.
Express	·400	205	1,900	6·1	2 7	7 5
,,	·450	330	1,800	6·5	2 7	7 2
,,	·500	444	1,800	6·4	2 6	6 10
,,	·577	592	1,700	7·15	2 10	7 7

B.—Military and Sporting Rifles.

Martini-Henry	·450	480	1,300	11·9	4 4	10 10

[The above figures are extracted from Mr. Walsh's book.]

Lee-Metford	·303	215	2,000	4·6	1 8	4 2
Mannlicher	·256	156	2,350	3·5	1 3	3 2

Taking first the Express rifles, we see that there is not one of them the bullet of which does not drop more than six inches in passing over the first 100 yards. That of the ·577

bore drops more than 7 inches. When, however, we come to consider the amount of drop at 200 yards from the muzzle, we find that it is by no means—as the uninitiated might naturally suppose—about double that at 100 yards, but about five times as much, and that it ranges from 2 feet 7 inches to 2 feet 10 inches. The drop at 300 yards is very noticeably greater, and amounts in three instances out of the four to more than 7 feet. That is, it is from eight to twelve times as much in the third 100 yards as in the first, whilst in the last 100 of the three the drop is between two and three times as much as that in the first two taken together. Startling as is this development of the amount of the drop as the bullet loses the speed of its advance and increases that of its fall, its effect is even more marked when we consider the consequences of an error in the estimate of distance. To take rather a strong instance, let us suppose that the distance, being actually 150 yards, is estimated to be only 100, that the rifle used is the ·577 bore, and that it is fired with the proper sight for 100 yards. The bullet between 100 and 150 yards drops 10½ inches, and will consequently strike just so much lower than the point which it was desired to hit. Now let us suppose that the distance is actually 300 yards,

but that it is estimated to be 250 yards. Between 250 and 300 yards the bullet drops 2 feet 9 inches, and will accordingly miss the point of aim, striking just so much below it. In other words, an error in judging the distance of 15 yards out of 300 gives the same result as one of 50 yards when a range of only 100 is in question.

But even this hardly puts the case strongly enough. We have supposed that an error of 50 yards is made in each case. It will be said at once that to estimate a real distance of 150 yards as only 100 is to make a very gross mistake. Quite true; it is a most gross mistake; and yet such is the fallibility of the human senses, that even grosser mistakes of the same kind are frequently made. It will be fairer to suppose that in each case the error made is to underestimate the distance by one-sixth. Then the 150 yards distance will be taken for 125 yards, and the 300 yards for 250. In this case the shot fired at 150 yards will strike about 7 inches too low, while that fired at the longer distance will, as before, strike 33 inches low. That is to say, a similar error will produce at double the distance an effect nearly five times as great as at the shorter range. Had a yet longer distance been taken by way of example, the discrepancy would have been even more in

proportion. Can there be any wonder, then, that to make accurate shooting where long distances have to be guessed at needs the help of the gods as well as the best endeavours of men?

When we take the military rifles, particulars of which are given at the bottom of the table, we find an even more striking difference in the "drop" at the various ranges. Let us first note that, although they are classed as military, they are also sporting rifles. For the Martini-Henry with its ordinary load, and even as a carbine, has for many years done, and still is doing, excellent work as a sporting rifle all over the world, and more especially perhaps in South Africa. That the smaller bores are coming into fashion for the same purposes needs no demonstration. The ·303 (Lee-Metford) has already slain its thousands of wild game; with its ordinary hard bullet against the buffalo, the rhinoceros, and even the elephant, it has proved its power to kill, although its habitual use in the pursuit of such game is by no means to be recommended. With a modified bullet of about equal weight and velocity, but with less penetration, and consequently greater wounding power where soft-skinned animals are concerned, it is a weapon better suited to shooting deer and antelope than any rifle which preceded it. The ·256 Mannlicher

rifle has likewise been proved very effective for soft-skinned animals, and we may expect to see its use extended. One great point in favour of these two small-bore rifles is the high muzzle velocity, which gives for sporting ranges a trajectory much flatter (as the table shows) than those of the ordinary Express rifles. While the bullet of the Martini-Henry, starting with a low velocity, drops about 25 per cent. more at the shorter ranges than those of the "Expresses," we may say that approximately the Lee-Metford bullet drops little more than half as much, and that of the Mannlicher a good deal less than half. It will be seen at once how great an advantage this gives to these latter rifles. To illustrate it from a practical example, the writer may quote the saying of a friend of his, a sporting shot of great experience and rare skill, that with the ·256 Mannlicher rifle (with which he has slain a good many stags) he is able to make certain of his shot, if it is a fair broadside one, up to 300 yards, and that if the animal be lying down he can take it in the neck up to 150 yards. This may cause old-fashioned sportsmen to open their eyes, but it is the most sober of facts, and the figures accompanying this paper—and they are by no means unduly favourable to the new rifles—show clearly enough that for many kinds

of game sporting ranges have now been lengthened by at least one-third. The man devoted to the double-barrelled Express may perhaps not take kindly to the notion of a single-barrel, even though it be fitted with a magazine holding five or ten cartridges. It must be remembered, however, that the comparisons above given have reference only to the shooting qualities of the barrel and ammunition, and that there is no difficulty in fitting the barrels to any form of breech action strong enough to withstand the strain which the charge imposes.

When really long distances are in question, the increased fall of the bullet with each fresh increase of distance becomes more and more marked. Thus, the Martini-Henry bullet, which falls not quite 12 inches in the first 100 yards, falls in 1,000 yards not 120 inches, but 145 feet. That of the Lee-Metford falls in the same distance 77 feet, and that of the Mannlicher about 63 feet. The Martini-Henry bullet of 480 grs. is heavier than the Express bullets in proportion to the surface which it opposes to the resistance of the air, and accordingly maintains its speed better. Consequently, though its fall in the first few hundred yards is greater than theirs, when we come to such ranges as 1,000 or 1,500 yards, theirs will be the greater fall. With all rifles the drop at the

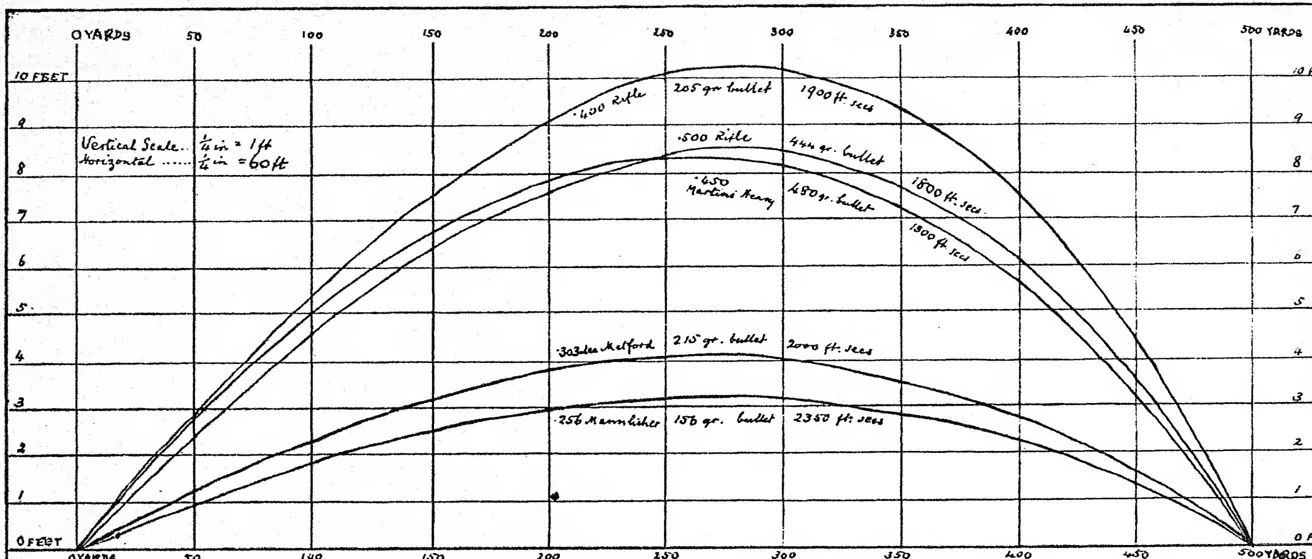
longest ranges is enormous. For instance, with the ·303, when a shot is fired at 1,500 yards, the barrel is directed towards a spot more than 230 ft. above the point aimed at, and at 2,000 yards 530 ft. above it, while at 2,500 yards, a distance at which the rifle is still effective to kill, the bullet when starting is pointed no less than 1,040 ft. above the mark.

It will be clear from what has been said how abundantly foolish a practice it is to put on sporting rifles sights professing to be suitable for long distances, at which we may be sure they have never been actually fired. "Sighted to 1,000 yards" may look very well in an advertisement, and may in some cases lead the ignorant purchaser into thinking that it endows the rifle with some talismanic virtue. But who can shoot game at such a distance as that, or, being in his senses, will attempt to do so? For, given more than all possible accuracy of aim and of the bullet's flight, an error in estimating the distance of 25 yards, or only 2½ per cent. of the 1,000 yards, will send the Lee-Metford bullet 3½ ft., that of the Martini-Henry 5 ft., and that of the Express yet further, above or below the mark.

CHAPTER VIII.

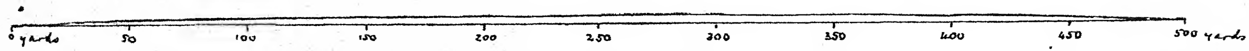
Of Trajectories.

It would hardly fall within the scope of our present intention to attempt to enter thoroughly into the more technical aspects of the flight of projectiles through the air. It would almost need an apology to treat once more in any fashion a subject which has been over and over again dealt with by various writers, were it not that it is the only way by which the increased efficiency of modern rifles can be well realised, and the full advantages noted which they confer on the sportsman or the marksman. In the last chapter we considered the general effect on the flight of the bullet of the combined forces of gravity and the resistance of the air, and noted how, if fired horizontally, the projectile falls in a curve that constantly grows in the steepness of its downward motion. It may now be interesting to take some practical examples, and to consider what is the actual shape of the curve which



The above diagram shows the comparative heights reached by the bullets of various rifles in a flight of 500 yards. To give a clear comparison between them, the height of the curves is enormously exaggerated in proportion to their length.

The small diagram given below indicates the true proportions of the coarsest of the curves



HEIGHTS REACHED BY BULLETS.

represents the course of a bullet in its flight to a mark, and to compare from this point of view the performances of the standard rifles which have already been taken as examples.

The human eye has, as is well known, an immense natural difficulty in judging the proportion between height and horizontal distance. It would be quite impossible to show clearly by a diagram such as could be contained in a page of the present book the difference in the flight of various bullets, and at the same time to show the trajectories in their true proportions. This is because the curve of any high-speed projectile rises to a very small height in comparison with the length of the distance it traverses. The general proportions of such a curve may be gathered from the small figure at the bottom of the plate illustrating this chapter, which gives a general view of the true shape of the coarsest of the curves shown in the plate. Little wonder, then, that to present in these pages curves of trajectory for purposes of comparison, it should be inevitable to compress the length of the range to an enormous extent, and so to give to the height of the curve vastly more than its proper amount. It is to be feared that those who cursorily inspect such a diagram as that now given are apt to carry away the idea that they have seen a picture of the flight of

the bullet as it really is. Hence this word of warning, which the majority of readers will not need.

It is perfectly obvious that, given similar bullets, that which leaves the muzzle with the highest speed will have the advantage, both in the directness with which it flies to the mark, and in the force with which it strikes it. It is also clear that of two bullets starting with equal speed, that which is lightest in proportion to the surface which it presents to the resistance of the air will be the more retarded by that resistance. Note, then, in the diagram how the comparatively light bullet of the ·400 Express (weighing only 205 grs.) rises in its flight of 500 yards higher than those of the other rifles given, and falls again in a steeper curve; yet its velocity on leaving the muzzle is 1,900 feet per second, much higher than that of the ·500 or the Martini-Henry. This is because the light bullet loses speed so rapidly. The heavier one of the Martini-Henry, on the contrary, though leaving the muzzle at a less speed —only 1,300 feet per second—maintains much better its velocity, and does not fall in so steep a curve. The trajectories here given of the ·400 and ·500 rifles are taken from Mr. Walsh's book, and the same author states that while the light bullet of the ·400 loses in its first 150

yards of flight 550 of its 1,900 feet of initial speed, that of the Martini-Henry loses only a trifle over 200 of its original 1,300 feet velocity. The same thing will account for the similarity in height of the curves of the ·500 rifle and the Martini-Henry, in spite of the fact that the former gives 500 feet more speed to its bullet than the latter.

The distance taken in illustrating these trajectories is 500 yards, which, it will naturally be said, is a very extreme distance from the sporting point of view. The differences, however, between the trajectories come out more visibly here than at shorter ranges. The base line from which the heights are measured is in all cases a line joining the centre of the muzzle at the instant of firing with the point struck. Thus the actual heights of the bullet above the line between its starting point and its finishing-point are given, but no account is taken of the line of aim, which differs from this because of the height of the sights above the barrel. This is no great amount, indeed, but it is large enough to be important at close ranges.

It will be seen from the diagram that the ·400 Express bullet rises to a height of rather more than 10 feet at 250 yards from the firing-point. This is a very large amount, although it is but little when compared with the much

more rounded curves of the rifles of fifty years ago. The highest point in the 500-yards curve of the two Express rifles is at about 280 yards from the firer, but it will be seen that with the other rifles, the bullets being heavier in proportion, the highest point is decidedly nearer the middle distance. It used to be said that the Martini-Henry would just strike a mounted man at any point of its 500 yards flight. Its bullet rises rather more than 8 feet. It will be seen that the general shape of the curves shows a very gentle increase of steepness, and that the angle at which the bullet descends is not very much more than that at which it rises.

The two lower curves in the diagram are, by comparison, startling. The Lee-Metford bullet rises to just half the height of that of the Martini-Henry, its whole rise and fall being less than fifty inches. But the ·256 Mannlicher shows a still more marked superiority, as its rise and fall is entirely within 40 inches. The bullets of the three military rifles are all very similar in their proportions, and the differences in their trajectories are mainly due to their various muzzle velocities. The Martini-Henry bullet starts on its flight at a speed of nearly 870 miles per hour, that of the Lee-Metford at 1,330 miles, and that of the Mannlicher at 1,570.

Now, let anyone unfamiliar with these things pace or estimate a distance of 500 yards, that is, a quarter of a mile "and a bittock," and try to realise that in those 500 yards the course of the ·256 bullet is so flat that it does not rise so high as his waist! Is it astonishing that such a curve conveys very little to the eye unless a good deal magnified?

We may here observe that, under some circumstances, the flight of the bullet in the air can be actually seen with the eye. The fat bullet of the old "Snider" was very visible through a telescope, and could easily be seen dropping on to the target at 200 yards. With the naked eye, from a point behind the firer, bullets may be watched under favourable circumstances, as when the sun shines on their base, and they are seen against a dark background. The writer has more than once watched the flight of Lee-Metford bullets, without difficulty seeing them flash across a dark hedge in front of the firing point, making a bright line of light in the rays of the sun, which were reflected from their polished sides, At long ranges, such as 1,000 yards, bullets can be seen with a good glass against the sky, and one after another can be "picked up" without fail, as it rises into the field of the telescope, and falls again out of sight towards

the target. But the glass must be almost directly behind the firer, and pointed to the proper spot above the target. It may here be noted that the bullet of the Martini-Henry rises about 44 feet, that of the Lee-Metford 25 feet, and that of the ·256 21 feet above the line of aim in a flight of 1,000 yards. Whatever the distance, the bullet continues to fly with its point in the direction in which it is moving, so that at the end of its flight the point is directed downwards as it falls. This, though at one time disputed, has long been established, not only from observation of the projectiles of large guns, which are easily watched, but also from examination of the form of the holes made by bullets striking after a very long flight.

This fact, in old days a subject of argument, is evidently due to the resistance developed by the air on the lower side of the bullet's length as the direction of its flight is gradually changed by the action of gravity. It is clear enough that in a vacuum there would be nothing to prevent the bullet from accomplishing its whole flight without in any way altering the direction in which it pointed at starting. No doubt it was the knowledge of this, combined with under-estimation of the resistance of the air, that led to its being

doubted whether a long bullet's direction conformed to the curve of its flight. It will be seen that a spherical ball presents an equal surface to the air in all directions, and that so there is no varying resistance to induce it to behave in this way. Consequently, when it begins to fall appreciably, the stress and pressure of dividing the air comes upon that part of the bullet which bears the imprint of the grooves and is most in motion as it spins. To this cause we may largely attribute the erratic behaviour of spherical balls at distances for which a material elevation has been given to the rifle.

It has been proved by experiment that a long-shaped rifle bullet fired vertically upwards descends base foremost. Clearly, it would have no tendency to turn over on reaching the summit of its flight, if the spin were still enough to steady it. And here may be mentioned a wide-spread fallacy, that a bullet so fired upwards from the ground will, on again reaching the ground, have attained once more the same velocity with which it left the muzzle. This would of course be the case if there were no air. But in the first place the resistance of the air prevents the bullet from attaining nearly so great a height as it would attain *in vacuo*. Again, in falling from the point which

it actually does attain, it cannot develope the theoretical velocity of fall which gravity would impart to it, because its fall is constantly impeded by the air. The air, in fact, retards during its whole flight, both upwards and downwards, the velocity which it would otherwise have in falling, with the result that it does not nearly regain its original speed. A simple demonstration of this fact can be given. Who, in covert shooting, has not now and again heard, or even felt, shot fall which was fired vertically or nearly so from his own gun or that of some near neighbour? A single pellet so falling bounds off him without even stinging; yet would he feel nothing more than this if struck by a single pellet just after it had left the muzzle? The same cause which retards the fall of rain drops, making them descend gently upon the earth, has in a large degree its effect upon all moving bodies, an effect which, even with the denser forms of matter, is still considerable.

The following table will, perhaps, not be without utility in showing at a glance the height to which the bullet has risen at the half-way point of flights of 100, 200 and 300 yards with the same rifles. The absolute highest point at these ranges is so near the mid-distance, and the rise after passing the mid-dis-

tance so very small, that for practical purposes we need make no distinction between the two. Indeed, when it is a question of determining the precise yard at which the bullet reaches its highest point, even thousandths of an inch are hardly fine enough divisions for the purpose. In the table it has not been thought necessary to carry refinement beyond giving the nearest tenth of an inch. The heights of the two Express bullets are (as before) taken from Mr. Walsh's book, and those of the others are calculated from the angles of elevation actually used at the different distances. The curves are naturally similar to those described in the last chapter of these Notes for the same rifles, the difference being that, instead of the rifle being fired horizontally, and the drop of the bullet below the horizontal line being measured, the "bow" of the curve is measured from the straight line joining the muzzle and the mark.

We find, then, that the deviation of the bullet's track from the straight line is but small at the nearer ranges. One inch and three-quarters will cover the rise and fall of the "Express" bullets at 100 yards, while the Martini-Henry requires 3 inches. But the Lee-Metford requires only 1·2 inches, and the ·256 rifle only ·9 inch to cover the curve of its course for the same distance. That is, if the

muzzle of either could be applied to a straight piece of $1\frac{1}{2}$ inch pipe 100 yards long, it would be possible for the bullet in its flight to traverse the whole length of the tube, and pass out at the other end without having touched the walls of it anywhere. Similarly, at the other distances, the rise and fall given by the two really "small-bore" rifles bears a wonderfully small proportion to that of the larger bores, and at 300 yards a 12-inch pipe would contain the whole trajectory of the ·256 rifle.

Table showing the heights reached by bullets at the half-way distance in flights of 100, 200, *and* 300 *yards.*

		In 100 yards' flight, height at 50 yards.	In 200 yards' flight, height at 100 yards.		In 300 yards' flight, height at 150 yards.	
		in.	ft.	in.	ft.	in.
Express	·400	1·6	0	9·5	2	5
,,	·500	1·7	0	8·9	2	1
Martini-Henry	·450	3·0	1	1·1	2	7·6
Lee-Metford	·303	1·2	0	5·5	1	2
Mannlicher	·256	·9	0	4·2	0	10·8

It must not be supposed that every individual shot from a rifle will, under the best possible conditions, follow the theoretical curve without deviation. It is very well known that it is impossible even at 100 yards to put a series of bullets each precisely on the top of the last. This is because it is impossible to reproduce shot after shot with mathematical uniformity. Even if the aim were so reproduced each time —as in a fixed rest it practically can be—one charge of powder is not absolutely equal to

another, nor is the igniting charge in the cap invariable, nor if these were always perfectly true would there be any guarantee that the ignition of the powder would always proceed at precisely the same rate. Then there are small variations in wads and bullets. The outcome of all which is that, without respect to accuracy of aim, it is impossible to get absolutely the same muzzle velocity out of each shot of a series. There will always be a certain variation, and the most that can be done is to reduce this within the smallest possible limits. Consequently, with all possible care in making up ammunition for experiment, the mean velocity has to be taken from the average velocities of a number of shots. Similarly, the theoretical curve made by the trajectory for any particular rifle and charge represents actually the average curve given by a number of shots at the range in question, checked by similar observations at other ranges. But any one shot fired will be found to deviate in at least a minute degree in one direction or another from the theoretical path, and a group of shots will all of them be distributed round it. No bullet, indeed, keeps an absolutely consistent course. Probably the heavy air-pressure on the head of the bullet, helped by any small irregularity of form or density, pre-

vents it from attaining the complete steadiness of a top when "asleep." Whatever the cause may be, it is undoubtedly the fact that if a close group of shots be fired at any considerable range through a succession of screens placed some distance apart, and each shot-hole be numbered as it is made in each screen, almost every shot will be found to vary, from one screen to another, its position in reference to the other shots in the group. The shot which is the highest in the group on the first screen may at the next have come towards the middle of the group, while another shot may have risen to its place. Some shots will show lateral motion. This curious phenomenon, from which the most accurate of rifles is not exempt, cannot be fully dwelt on here. It must suffice to say that the wonder is not that each shot should not absolutely follow the curve without deviation, but rather that the deviations from it made at any range by a good rifle should be so small as they are, especially with ammunition which has been turned out in quantity, and therefore cannot be very precisely uniform.

The preceding remarks refer to single-barrel rifles, from which great accuracy is to be expected. With regard to double-barrel ones the case is somewhat different. It is extremely

difficult to join two barrels side by side, so that they shall shoot to exactly the same point, and the group of shots made by the left barrel at (say) 100 yards coincide with the group made by the right. It will be found that the two barrels of an Express rifle are not set with their bores parallel to each other, but that they converge very appreciably towards the muzzle. This is, as has been mentioned in an earlier chapter, because the recoil motion begins before the bullet leaves the muzzle, and tends to throw the muzzle of the barrel fired in a slight degree outwards from the middle line along which aim is taken. This amount of side-throw, then, has to be allowed for in setting the barrels, when the amount of it has been ascertained for the individual rifle and the particular charge to be used in it. The heavier the charge, the more it will amount to. Also, the two barrels must be set so as to throw their bullets vertically to the same spot. All this requires very nice and very careful manipulation, and it is one of the snares of cheap "doubles" that they are so rarely regulated properly in this respect. The writer has known several such, and well remembers trying for a friend a double Express, of which one barrel at 100 yards put its shots quite a foot from those of the other, so that two distinct groups were made on the target.

Another rifle, by an expensive maker, made two groups a foot apart at sixty yards. What a bungling this might have led to in a shot at a stag! Nay, what bungling shots have undoubtedly been made from this cause! Difficult as it is to get the barrels of a double rifle to come together, it is so essential a matter that there is no excuse for any great inaccuracy in this respect, and all new rifles should be carefully tried with the view of checking them in this point. It should also be remembered that when a pair of barrels do shoot together their shooting can be spoilt by quite a slight blow against (for instance) a stone in the course of a stalk. Here is good reason for taking proper care of a good rifle. People are much too apt to think that firearms are made to be knocked about. On the contrary, they are very delicate instruments, and their perfections are quite easily impaired.

CHAPTER IX.

Of Velocities.

In using a rifle the allowance for wind follows much the same lines as that for elevation. In the earliest stages of the bullet's flight, say for the first 100 yards, little allowance need be made for the effects of a cross wind if the velocity be high. But as soon as the distance is increased, and the wind has a longer time to act on the projectile, a proportionate allowance must be made. For the amount required there is no universal receipt and no golden rule. Only experience can help; for the amount of the allowance will vary not only with the range, but also with the force and direction of the wind, and, further, with the weight, form and velocity of the bullet. Fortunately, most of the shooting with sporting rifles is at distances so short that the allowance for wind is trifling. In a long shot, however, it cannot be ignored with impunity. Nor must it be supposed that the lateral deflection is the

only effect of wind. It is one of the commonplaces of rifle knowledge that a head or a rear wind will affect the elevation required at any distance. That it must be so is obvious. It is the resistance of the air, as the projectile cleaves its way through it, which diminishes its speed and shortens its range by an immense amount, as compared with what they would be *in vacuo.* Consequently, anything which diminishes this resistance, or increases it, will affect the distance travelled by the bullet in a given time. If we imagine a bullet travelling with a hurricane blowing in the direction in which it is going, it is clear that it will not have to cut its way through so large a quantity of air, in any given distance, as it would if the atmosphere were still. Therefore it will not have lost speed to the same extent, and it will have traversed the distance in less time. And in the less time obviously the amount of its fall will have been less. Hence it will strike a mark at a given distance above the normal place with a strong (or any) rear wind. ? head With a wind from the front adding to the amount of air through which the bullet has to force its way, it will evidently have been delayed, and have had time to fall more, in its flight. Although these effects are always present, their amount is not such as to need special allowance

at the shortest distances. It is, however, the different amounts of allowance which have to be made—and often varied from shot to shot—to meet the effects of wind blowing from the side, the front, or the rear, which constitute the chief difficulties which the target marksman has to face. In firing at the longest ranges his powers of observation and judgment are taxed to the utmost. Thus during the Bisley meeting of 1894, for several successive days the wind blowing across the range was so strong that the average allowance for it at 900 yards with the ·303 was 22 feet, just the distance to the middle of the bull's-eye of the next target. Even greater allowance than this has at times to be made, and, of course, varied with every shift of the wind. At 1000 yards, with a strong opposing wind, the shots will strike as much as 8 to 10 feet higher than with a similar wind following the bullet. The influence of the wind on either direction or elevation is, however, by no means so great in proportion to the shorter distances.

Lower?

There are two other conditions affecting the resistance which the air offers to the bullet, which it is well to note. One is the mere effect of temperature. With cold the density, and with it the resistance, of the air increases, and with heat it diminishes, although

not to a sufficient amount to affect materially the flight of the bullet at sporting ranges. With a high or low barometer there is a similar effect. It would seem as if this, too, were a matter of only academic interest, and of merely nominal effect. But under some conditions it becomes much more. The fluctuations of the barometer at any place mark changes of density which are too small to be of appreciable importance. But it has been well established that in high mountains, where the barometer always stands low and the air is rarefied, the diminution of resistance to the bullet is so great as quite to destroy the value of a scale of sighting, even at short ranges, which is suited to the ordinary conditions of the sea-level. On the heights of Cashmere or the Rockies, therefore, it may save the sportsman from mishap if he will recollect that it is wise to shoot his rifle at a few measured distances, to check the correctness of the sighting in the changed conditions of high altitudes.

One kindred matter, although at short ranges an unimportant one, may here be touched upon. This is the well known phenomenon of "drift." It is found that a bullet or shell tends, in the course of its flight, to depart laterally from the line in which it was projected. With a right-handed spiral the drift is to the right, and with

a left-handed spiral to the left. The amount of it is not very great; with the ·461 Match rifle at 1000 yards it is about 2 feet 6 inches to the right, while with the ·303 it is to the left. The amount of it with the latter rifle at this distance is said to be about 1 foot 6 inches—a figure which, in the writer's opinion, is hardly large enough.

This sidelong motion is of more importance to artillerists than to riflemen; it need practically not be taken into account at sporting distances, although at long ranges allowance has to be made for it. One simple and widely-accepted explanation of drift is that the bullet, as it falls, slightly compresses the air below it, while the air in contact with its upper surface is correspondingly rarefied. So, having, as it were, a cushion underneath it, the bullet, since it is spinning over and over sideways, tends to roll to one side upon the cushion. The writer, however, thinks that this is by no means the whole explanation, but that the phenomenon depends largely on the same pressure of air on the under side of the bullet, which keeps its axis constantly tangential to the curve of its flight. It would, however, be going beyond the purpose of the present chapters to go fully here into this subject. It is enough to note the fact of the deflection, and that there is no general agreement as to its exact causes.

From what has been said, it will be clear enough that the effect of the resistance of the air is the most important factor influencing the flight of missiles. This, indeed, hardly required to be stated. Every schoolboy (unless perhaps it were Lord Macaulay's proverbial prig of a youth, who must have had a soul far above a boy's usual outdoor amusements) knows that if he wants to hit a bird, a stone—the natural missile of mankind—can be thrown from the hand faster and further than a piece of wood of similar size. And, when he advances in knowledge and science through the pea-shooter stage to the use of the catapult, experience soon shows him that a buckshot is far more effective than a pellet of hardened clay, a small stone, or a marble. The reason is to him obvious enough. He will tell you that the buckshot is "heavier" (meaning thereby in proportion to its size) than the others, and that it flies faster and straighter and hits harder than they—that is, that it retains its speed better. He quite realises that the heavier in itself a substance is, the more effective a missile it makes. It might appear impertinent to dwell even for a moment upon this well-known fact, were it not that, obvious as it is, it seems sometimes to be overlooked. It is not very long since a paragraph went the

round of the papers, in which it was gravely stated that a San Francisco inventor was carrying out experiments with aluminium bullets. These, it was said, promised extremely well, and would have the especial advantage of reducing the weight to be carried by the soldier. Now the general use of lead for rifle bullets is due to the fact that it is the heaviest of the common metals, weighing bulk for bulk more than eleven times as much as water. Consequently, the mass of a leaden projectile offers a much smaller surface to the resistance of the air it penetrates, and therefore better preserves its velocity than any body of equal weight but larger bulk. Although a pound of lead and a pound of feathers both weigh sixteen ounces, the latter would make a peculiarly ineffective missile. For small arms, consequently, lead has superseded iron and steel, which are only from seven to eight times heavier than water. Aluminium will, no doubt, come into use for many purposes now that it can be produced cheaply; but it is safe to say that if there is one purpose for which a metal less than three times as heavy as water is singularly ill-adapted, it is that of making bullets.

The heavier the metal is, the better for this purpose. Silver, which is slightly less heavy

than lead, used to be recommended as particularly effective against a charmed life. In the present day, our preference is, for very sound reasons, in favour of the more unromantic metal. If, however, the depreciation of silver were to be redressed by an enormous production of gold, and the mines of Johannesburg and Western Australia were to flood the world with it until, like silver in Solomon's days, it should be 'nothing accounted of," we should have the command of a metal decidedly more suitable, and that for no supernatural reason, for bullet-making than lead. For gold is, bulk for bulk, more than nineteen times as heavy as water, and 7 oz. of it occupy no more space than 4 oz. of lead. It is at least as improbable that either platinum or iridium, which have respectively twenty-one and twenty-two and a-half times the weight of water, should ever be available for bullets. Another exceptionally heavy metal, which may be named in this connection, is tungsten, which is half as heavy again as lead.

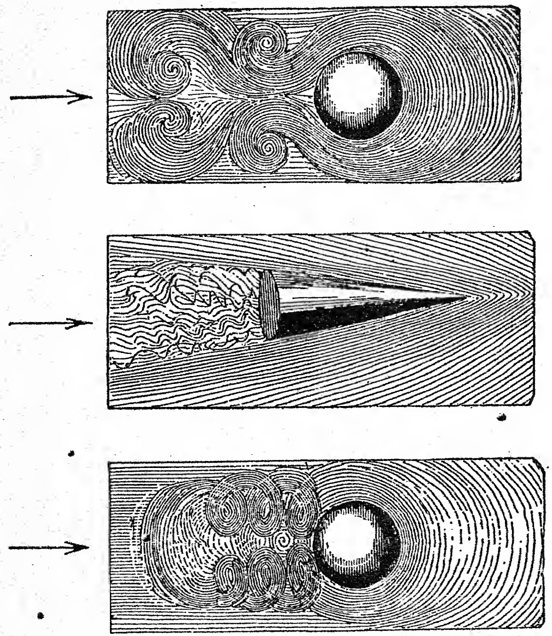
It is curious to note that all the earliest cannon seem to have been made to fire round shot made of stone, in many cases of very large dimensions. Probably at first iron balls could not be produced easily or cheaply enough for common use. But it was not very long

before they began to supersede the stone shot, and it must rapidly have become evident that a greater effect could be obtained from a cannon of moderate size firing iron shot than from a larger and less manageable one (and they were made up to 3 ft. in calibre), loaded with balls of stone. Many materials and forms have been tried for cannon balls at different times and in emergencies. In the arsenal at Tokio in Japan may be seen round shot made of earthenware, with a glazed surface. Endless varieties of chain shot and case shot have at different times been adopted for special purposes. In the museum of the Royal United Service Institution the remains of a wooden canister shot filled with flints may be seen: it was taken from a very ancient submerged wreck off the coast of Essex. Even such primitive missiles must have been effective at the close quarters in vogue in the early days of cannon.

The progress of the last hundred years has, in a sense, enabled some of the advantages of a heavier metal to be obtained from leaden bullets. So long as the balls used were spherical, their ballistic efficiency was limited by the density of the metal. But as soon as they were put into a form combining smaller diameter with an elongated shape, the surface

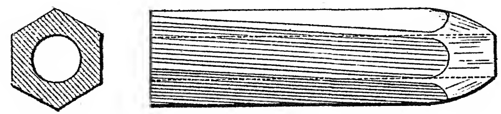
opposed to the air in flight was so reduced as enormously to diminish the resistance, and advantages were at once realised which only a metal heavier than gold could have given with the old form of bullet. Thus it comes that the efficiency of a bullet for flight is measured by the proportion between its weight and the size of its transverse section. *Cæteris paribus*, it is an object to keep the latter as small as possible, since a bullet of small diameter will the more easily force its way through the air.

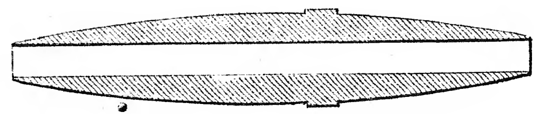
The amount of the resistance of the air to the bullet's flight is enormous, and it is multiplied with every increase of speed of the bullet. It is said that at a speed of 2,200 feet per second the resistance of the air is 28 lbs. to the square inch. In other words, a Lee-Metford bullet (which weighs only half an ounce) moving at this speed through air would meet with as much resistance as if it were moving in a vacuum, and dragging with it a weight of 2¼ lbs. We are used to recognise how considerable is the pressure of the air, which amounts to 14 lbs. on the square inch, but here is a resistance, to be overcome by the bullet, of nearly double the pressure that can be got by suction. No wonder, then, that bullets moving at high velocities rapidly lose



Diagrams showing air-disturbance
from Hans Busk's "Handbook to Hythe." 1860.

Sir Joseph Whitworth's ·450
hexagonal tubular bullet
1858.





Section of the Krnka-Hebler
Tubular bullet
1893.

a large proportion of their speed. It is only within the last two or three years that the photography of flying bullets has shown the actual disturbance of the air caused by them, but it is very fairly indicated in the plate, which reproduces the air waves around and behind bullets as imagined by Hans Busk in a book published thirty-five years since.

The shape of the bullet's head is, of course, a very important factor in the ease with which it cleaves its way, just as the precise lines of the bows are vital to the speed of a racing yacht. It is found, however, that the shape of the absolute point is of much less importance than the slope of the shoulder where it joins the cylindrical body of the bullet. It is naturally an old idea that the shape of least resistance will be one in which the body gradually tapers away (like that of a ship) towards the stern, and this is indeed the fact. Robins thought well of an egg-shaped ball, and in later times Sir J. Whitworth adopted a form of shell with a tapered base. But the theoretical advantages of this form were not found to compensate for the difficulties to which it gave rise, and this is especially the case with small arms. For a flat or hollow base of the full diameter is of great assistance in sealing the bore, and preventing the gases of the explosion from

rushing round and past the bullet as it moves up the barrel.

Here, too, we may notice a form of bullet, brought into prominence two years since, as a new invention, which, after creating a great sensation for a short time, seems to have subsided again into the silent land of failures—the tubular bullet. It would have been odd if the constant desire of man to vary the form of projectiles had not long since led to experiment with this form of bullet. We find, accordingly, that Sir Joseph Whitworth, in the course of his experiments, devised such a bullet. Like all his small arm projectiles, it was hexagonal, and of ·45 inch calibre. To avoid any reduction of weight, it was made much longer than his solid bullet It was not tapered at the base, and had a hollow of $\frac{1}{4}$ inch diameter, and open at both ends, running through its whole length. It was fired with a wooden wad or shoe behind it, to prevent the gases of the explosion escaping through the tube. He thought highly of this form of bullet for piercing elastic substances, as it was found to take out a core in passing through them. He had also a particularly good opinion of its effectiveness against solid substances. "They penetrate deeper into masonry than any other projectile I am acquainted with," he says.

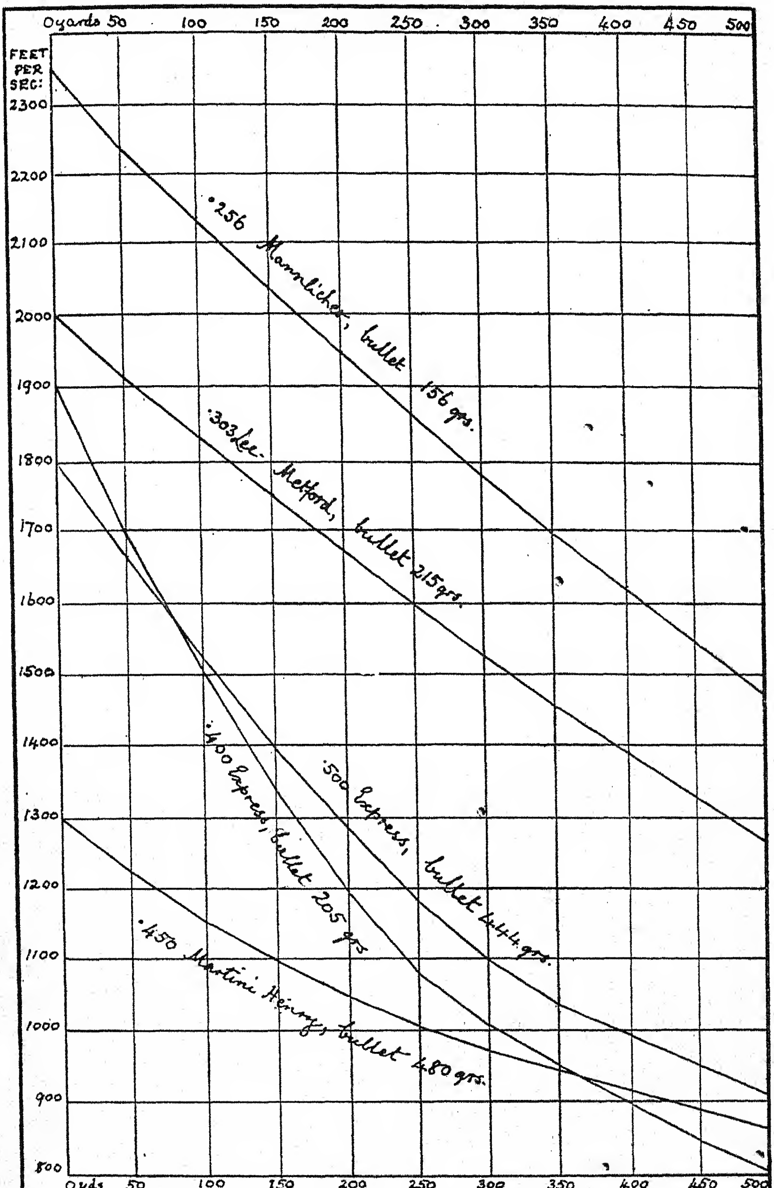


DIAGRAM OF VELOCITY CURVES

for 5 selected Rifles, showing the bullet's loss of speed in traversing the first 500 yards from the muzzle –

It is clear that these advantages were thought to be counterbalanced by the increased bulk of this form of bullet, for it does not seem ever to have gone beyond the experimental stage. So entirely had Sir Joseph's experiments, in this particular, passed out of mind, that when about two years ago it was announced that a well known Continental inventor had patented a tubular bullet that was to revolutionise projectiles, the statement met with much credence. Nor was this allowed to rest only on general statements. Figures were gravely given, as if obtained from actual experiment, which set forth that the Krnka-Hebler tubular bullet not only gave much higher results at close ranges than bullets of the ordinary form, but maintained its velocity and its penetration in a fashion hitherto unheard of. Giving (as no doubt it did) a muzzle velocity in the Hebler ·197-inch rifle of 2,966 feet per second, with a penetration (presumably into timber) of 33 inches, it was said that at 1,094 yards its velocity was 2,585 feet, and its penetration 34¾ inches, while at the extreme range of 2,734 yards its velocity had not fallen below 2,106 feet, nor its penetration below 30¾ inches. Such figures, no doubt put forward in the most perfect good faith, and throwing into the shade all recorded perform-

ances of small arms, indicated nothing less startling than a revolution in gunnery. But the revolution has not come. It has been found impossible to obtain results at all proportionate to the anticipations raised, and the tubular bullet is not accepted as superior, in ballistic qualities, to the solid one. Indeed, its use seems only to entail practical difficulties and complications which are likely to keep it permanently in the background. If it should be asked how it came that such astonishing statistics of performances were given, we can only conjecture that they were built up by theoretical considerations, unchecked by actual experiment, and no doubt founded on insufficient and probably erroneous data obtained from experiment at short ranges. Theory in such matters cannot, unfortunately, be implicitly trusted as a guide any further than it admits of being verified by actual experiment. Here is an ancient instance of a similar fallacy from R. Anderson's book, "Cut the Rigging, and Proposals for the Improvement of Great Artillery" (1691). Having given particulars of the results given by a "Saker," a 3½ inch cannon, which was found to have an extreme range of rather more than 5½ miles, he deduces that the greatest range of a musket will be just under 5½ miles, and points out that if

a fowling-piece be made with a barrel 8 feet long and $\frac{7}{10}$ inches in calibre, "such a piece (certainly) will range its ball 10 miles (the air excepted)." The *naïf* exception at the end, added evidently rather from a desire to be extremely accurate than from any belief that it was material to the result, is quite worthy of the man who in a previous work on the same subject confesses himself to be "no practical gunner," but proudly adds that he proves his statements by "Mathematical Demonstration, which is more satisfactory than Mechanic Tryal!"

Thus much having been said as to the great possibilities of error which arise when theory only is considered, it must be confessed that the accompanying plate, which represents the gradual diminution of speed of our selected bullets in a flight of 500 yards, cannot claim to be drawn up from results actually obtained by experiment. Even to say that the figures which it conveys are "generally accepted" or "taken from the best authorities" (as indeed they are) is not to establish their infallibility. Wherefore no such claim is made for them here. But, in default of other data, they may certainly be taken as near enough to the truth to represent fairly the comparative behaviour of the different sporting bullets represented. Thus

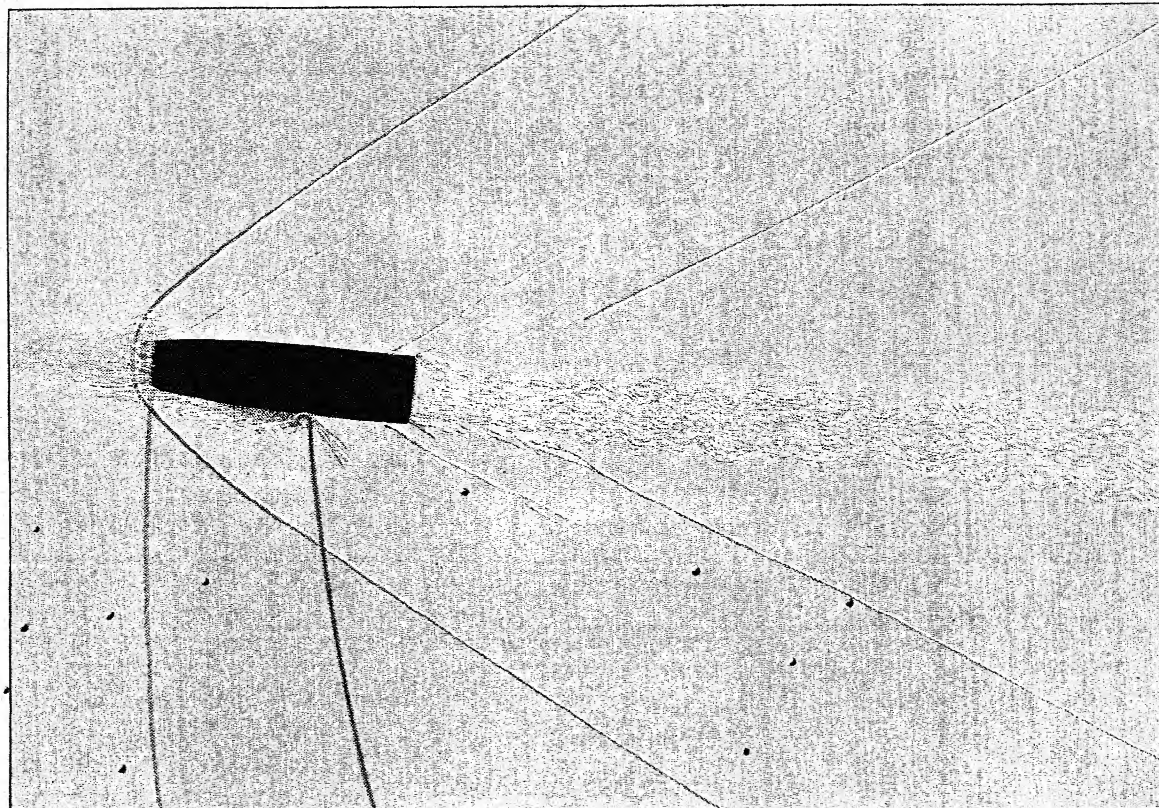
the curve of diminishing velocity of the ·303 bullet is given in the official text-book, and may be taken to correspond closely with the results of such official trials as may have been made. But for the curve of the ·256 Mannlicher bullet no data were available, and it has been worked out on similar lines to the ·303; this curve is, however, probably rather too favourable, as the head of the foreign bullet is less well-shaped for passing through the air than that of the Lee-Metford, and consequently it must lose velocity a little more rapidly. The curves of the Martini-Henry and the two Express rifles are formed from the data given by Mr. Walsh in his book. The lines of the two latter are, it will be noticed, not very consistent in the rapidity of their curvature, and we may suspect that the effect of experiment would be to correct this. But the general tendency is, as we should expect, unmistakable. The bullets of the little-bore rifles, light as they are, and moving at high speeds, cut easily through the air, because of their small diameter. The ·303 bullet still preserves at 1,000 yards a velocity of 993 feet per second, a higher one than that of either of the three rifles of larger calibre at 400 yards. Yet observe how small this velocity is beside that of 2,600 feet, falsely attributed to the Hebler

tubular bullet at this distance. The balls of the two Express rifles being light, and also offering to the air a large proportionate resistance, lose very rapidly the good velocity with which they start, as the steepness of the curves shows. The very light bullet of the ·400 rifle loses within the first 100 yards the advantage of 100 feet per second which it has at first over that of the ·500 rifle, and just beyond 350 yards falls to a lower velocity than that of the Martini-Henry bullet at the same distance, although the latter started at a speed of only 1,300 feet, as against the 1,800 of the former.

We are enabled, by the kindness of Mr. Kinsley D. Doyle, of the Royal Small Arms Factory, Enfield Lock, to give some pictures of bullets in flight. These were taken by him after the method so ingeniously devised by Professor Boys, and may properly be called "skiagrams" rather than photographs, as they are shadow pictures obtained by the flashing of a spark beyond the bullet while it is passing in front of the sensitive plate. The extreme shortness of duration of the spark may be judged from the very small advance of the bullet while the picture is being taken, though it is moving at a pace of many hundred feet per second. The slight cloudiness of outline at the bullet's tip and base is almost entirely

due to the longitudinal shape of the spark. The flash lasts about one-third of the millionth part of a second—a division of time more easily spoken of than realized.

We may just draw attention once more to the chief points of interest in these pictures, although Professor Boys has already very completely described the phenomena recorded by them. The frontispiece shows a Lee-Metford Service bullet in flight, with scarcely anything lost of its initial velocity of 2,000 feet per second. In this, as in the other pictures, we see the two wires with which the bullet has to make contact in order to close the circuit and produce the instantaneous flash which throws its shadow upon the plate. The air waves which Professor Boys has so thoroughly investigated are well shown, and the steepness of the angle at which the leading one slopes back from the bullet indicates the high speed at which it is moving. Professor Boys has shown that these waves are only created when the bullet is travelling at a speed higher than that of sound—1,100 feet per second. A line indicating a similar wave follows close behind the bullet, and smaller waves may be seen to flow from the slight irregularity in its outline made by the cannelure, the groove close to its rear end.



Lee Metford compound hollow-fronted Sporting bullet in flight. Weight, 180 grains. Velocity, 2,100 feet per second. See page 135.

The wake of the bullet is shown by the disturbance of the air, which appears almost to be pulverised as it rushes in to fill up the partial vacuum behind the bullet.

The second picture given is that of a hollow-fronted compound sporting bullet fired also from the Lee-Metford, its initial velocity being 2,100 feet per second. Here we have similar phenomena of air disturbance, with the addition of a curious disturbance in front of the nose of the bullet—due possibly to the movement of air into and out of the hollow in its point. It is interesting to notice how the small fragments of metal from the hinder wire form a dense cloud below the bullet, and how the end of the wire itself is being bent over into the form of a hook as the bullet passes along it. The central line of this bullet is so far from bisecting the angle formed by its head-wave, that we may suppose it to be considerably gyrating or wobbling in its flight.

The velocity with which a bullet starts upon its course, depends—it need not be said—upon the amount of powder behind it. A large charge will give it more velocity than a small one. Similarly, the velocity which a bullet will acquire from a given charge of powder will be more, *cæteris paribus*, in a long barrel than in a short one. This is simply because the expan-

sive power of the powder gases is not nearly exhausted by the time the bullet gets to the muzzle in a barrel of any practicable length. So that it is true that some advantage can be gained in velocity by adding a little to the length of the barrel. The ancients were well aware of this. There is at Bâle a single wheel-lock musket, of ·6 in. calibre, and fitted with an aperture backsight, which has a barrel 8 ft. 8 in. long! This is a 17th century weapon. But in fact, with a charge of powder that is suited to any rifle, there will be little advantage in adding, say, a couple of inches to the barrel, as the gain in velocity will be more than counterbalanced by the increase of weight and the loss of handiness. The ·461 match bullet acquires in the 33 in. barrel of the rifle, with a charge of 80 grs. of black powder, a velocity of rather over 1,300 ft. per second. A barrel 34 inches long will give less than 10 ft. addition to this speed. But an addition of 1 in. to the length of the shorter barrel of the Lee-Metford will, with the cordite cartridge, add nearly 50 ft. to its speed of 2,000 ft. per second. And, indeed, we should expect the velocity to vary in this respect much more in the small-calibre "high-pressure" rifles, in which a great speed has to be imparted to the bullet on a very small area of base in a very short time,

than in those in which the action of the powder is developed upon a larger area of base, and is, so to say, more deliberate, and imparts a lower velocity. Here we touch upon one of the leading points connected with latter-day improvements in firearms, that whereas in the 12-bore gun the maximum pressure given by an ordinary charge is from 1 to 4 tons per square inch, and with ordinary Express rifles somewhere about 8 to 10 tons, with the ·303 it is from 15 to 19, and with the Mannlicher ·256, about 23 tons, per square inch. This fact bears testimony to the great excellence of modern workmanship, material, and design.

CHAPTER X.

Of Impact.

In the course of the preceding chapter we considered the effect of the air in reducing the velocity of the bullet. We may now glance at the final arrest of its progress when it finds its billet, and consider what effects it produces at that moment, and how those effects may be varied so as to secure the desired result in particular circumstances.

Every missile in its course may be regarded as carrying with it, in a stored-up form, and ready to be developed the moment it meets with obstruction, a certain quantity of work, which has been put into it in order to project it. This work, or energy, as it is called, has two elements—the weight of the projectile, and the speed at which it is moving. The amount of the energy is constantly being reduced as it flies by the loss of speed due to the resistance of the air. Given the velocity at any point, the energy of a bullet of known weight can be

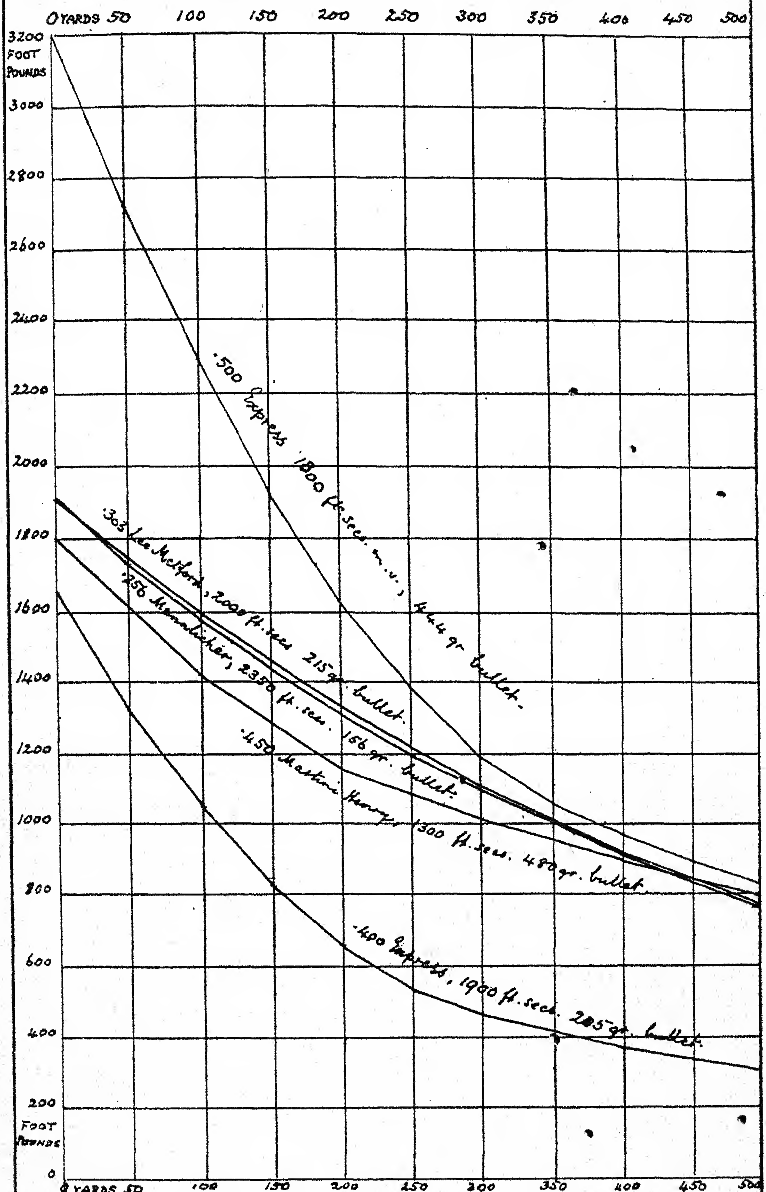


DIAGRAM OF ENERGIES

Showing the amount, in foot-pounds, of the force of the blow given by the typical rifles, and its gradual diminution in the first 500 yards of flight.

ascertained in the units of work known as "foot pounds," in the manner described in Mr. Walsh's book and elsewhere, and thus comparison may be made between different weapons. Such a comparison is shown in the diagram now given for the rifles and charges previously taken as examples, and the amount of the blow given by the different bullets at the muzzle may be compared, and its subsequent falling-off noted.

In the composition of the figure representing the striking energy, velocity takes a much larger part than weight. If the energy of a bullet moving at a given speed be represented by the figure 1, then if the weight of the bullet be doubled, the velocity remaining the same, its energy will be expressed by the figure 2; if trebled, by the figure 3; and so on. But if, the weight of the bullet remaining as at first, the velocity be doubled, the energy will rise from 1 to 4; if it be trebled, to 9; and if quadrupled, to 16; and so forth. It is upon this peculiar property of the velocity that the high-speed rifles of these latter days depend for their effect. Take, for instance, the Lee-Metford. Its little bullet, weighing only 215 grains, seems beside that of the Martini-Henry to be hopelessly inadequate to give an effective blow against game of any size. This is the

first and most obvious criticism made by almost anyone seeing the two together for the first time; and it is a perfectly natural comment. The Martini-Henry bullet weighs 480 grains, and when projected from the muzzle with a speed of 1,300 feet per second gives a striking force of 1,799 foot pounds. The Lee-Metford bullet, weighing 215 grains, will, with the same speed, give an energy of only 806 foot pounds, which is less in direct proportion as the weight of the bullet is less. But the Lee-Metford gives to its bullet a speed not of 1,300, but of 2,000 feet per second, and with this velocity it developes an energy of no less than 1,907 foot pounds. Thus the energy is a good deal more than doubled by an increase of 50 per cent. in the velocity. To double the 1,907 foot pounds of striking power, it would only be necessary to increase the velocity from 2,000 to 2,828 feet per second.

Yet it must not be forgotten that the important point is not what the blow will be which the bullet is capable of giving when leaving the muzzle with its full speed, but what force it will retain when striking an object after it has flown some distance through the air. Here the bullet which in proportion to the size of its cross-section has the greater weight will have the advantage. Also high speed means

rapid loss of speed. The falling-off of the energies shown in the present diagram depends upon the loss of velocity, as represented in that given on page 127. The curves of the two Express rifles, it will at once be noticed, are steep in their early stages, and show a very rapid loss of force. Thus, the ·500 rifle loses half its striking power in the first 200 yards of the flight, and soon descends to the general level of the Martini-Henry and the small-calibre rifles, which at very close ranges give less than two-thirds of its blow. The energies of these four rifles are all about equal between 400 and 500 yards. The ·400 rifle with its very light bullet is at first not much less effective than its neighbours, but it rapidly falls off in power; at 150 yards from the muzzle it has only half its original striking effect, and at 350 yards, only one-quarter, giving at its best a comparatively feeble blow. Clearly, to succumb to such a charge an animal must be easily knocked out of time, or the bullet happen on a vital point. So a very little consideration shows that if it is to be really effective for game of any size, a considerable increase in the charge of this rifle is necessary, and that the amount of either the powder or the lead, or more probably of both, should be larger.

Such facts as these, albeit somewhat dry in their first aspect, yet are the "dry bones" which, when clad in a practical form, govern the prospects of success in sport of all kinds in which firearms are employed. The largest elephant rifle and the gallery rifle of the most miniature proportions—nay, even in many respects the shot-gun—have the quality of their work judged on precisely the same principles. A blind and perfect faith in one's gunmaker is no doubt a beautiful moral phenomenon, but it may prove a disappointing substitute for a little sound knowledge on such matters as this; for there are gunmakers and gunmakers, and many of them are not so conversant as could be wished with the elements of rifle science. And when the blind lead the blind, is not their fate proverbial? Therefore, let the man who needs weapons suited to special requirements, if himself lacking in special knowledge, take heed that his gunmaker is thoroughly competent to advise on both rifle and ammunition. Else shall disappointment or even danger wait upon him in some critical hour, and, it may be, after failing to stop the biggest tusker or the finest stag of his experience, he shall discover in a bitter moment that regrets are vain, and even swearing, like force, "no remedy." Are we

not always learning lessons from painful experience? Take, for instance, the Lee-Metford. How is it that the Chitral expedition has given rise to a crop of complaints that this rifle has not shown itself entirely satisfactory in actual warfare? It seems to be proved clearly enough that in that campaign the stopping-power of our Service bullet was insufficient, else there would not be well-authenticated stories of men being perforated more than once without material injury. An especially remarkable case of this kind was that of one of "our friends the enemy" who was wounded in half-a-dozen different places by the fire of the British soldier, and two or three days later walked into hospital nine miles away, complaining that he was suffering from a stiff neck in consequence! Take, again, the cases of wounds inflicted when the mob was fired on at the Featherstone Colliery riots. One man had a shot through the middle of the bone known as the *radius*, about 2 inches below the elbow. The bullet bored a very small clean hole, "like a gimlet-hole," it was said, without shattering the bone. Another was struck by a bullet just below the right hip—he was standing sideways to the line of fire. The bullet, instead of penetrating into the flesh, kept a course under the skin, and passed

right across the lower part of the body. It then found an exit under the left hip bone, and lodged in a fleshy part of a man standing close by, who ran home, clapping his hand to the injured place, and crying that D. (the other wounded man) had shot him behind with a revolver! Neither of these wounds were at all serious. The late unfortunate fighting in the Transvaal similarly affords instances showing how much more humane are the effects of our present service rifle than those of its predecessors. It is satisfactory enough that in such cases as I have cited British lives should have been saved from danger; but the boot is on the other leg when we have to deal with our foes. It is said that in Chitral, after the fighting was all over, the freely-expressed opinion among our late enemies was that, could the campaign have been fought over again, our troops would have met with a much more stubborn resistance, so much has the moral effect of our magazine rifle fire been discounted by the innocuous character of the wounds it makes. So it seems that even humanity may be carried too far.

Here it may be noted as a well-recognised fact that it requires a much more severe wound to stop the rush of a savage enemy than that of a well-cared-for European soldier. But

allowing its full weight to such an argument, is not the largest part of our fighting done against enemies who are by no means highly civilised? How, then, does it come that the ·303, which has established an excellent reputation as a rifle for game, should be found wanting when employed against one of the least protected of thin-skinned animals—man? The answer is a simple one, and has application to the projectiles of every kind of rifle.

The Express rifle—and the ·303 in its essential features comes within this class—has been defined as one which gives to its bullets an initial speed exceeding 1,600 feet per second. It should be added that it carries a comparatively light projectile, which is usually hollow-fronted. Thus, its bullet has very great speed, and, on striking, meets with so much resistance (for the resistance increases more than in proportion to the velocity) that it is shattered almost before it has penetrated any distance, and this more especially if it should meet with a bone near the surface. Indeed, the desire to obtain a complete shattering of the bullet tended at one time to be pushed too far, so that some of the Expresses of recent times carried a bullet which was far too light and fragile. Indeed, the Express bullets in the charges which we

have taken from Mr. Walsh's book to illustrate trajectories, err decidedly in this direction. In the ·4 bore, for instance, a bullet of 360 grs. is far more effective for general purposes than one of 205 grs. So far has the tendency to reduce the weight of the bullet been carried that in some instances the only effect of hitting a beast of any size was that the projectile was broken up into very small fragments just under the skin, without reaching deep enough to strike a vital part. This is, no doubt, why the late Sir Samuel Baker, writing as a veteran of the widest experience in different parts of the world, insisted strongly on the necessity of using a heavy bullet of such a form as will not break up too easily. This, too, is why the sportsman in Africa commonly carries two sorts of cartridges for his Express rifle, so that he may use either solid or hollow bullets at will, even at the cost of the complication arising from the different sighting required by the two. For different animals require different forms of projectile.

It has often been said that the ideal bullet for any animal is such as, although propelled with a high velocity, will expend all its energy without penetrating, in the case of a broadside shot, the skin on the further side of the body, though it should reach so far as to touch it.

If such a criterion as this is to be adopted, it is evident that the load must be varied. For the bullet which will strike, for example, an antelope so as to pierce the skin and break up into fragments just before it reaches the vital organs, must be very different from that which is so arranged as to do most damage to an elephant, or to rake a giraffe from stem to stern. In a letter published a short time since in the *Field* newspaper, Mr. Selous gives a list of the game killed by him recently with the ·303 rifle, and says that out of thirty-eight animals he hit with it, only one escaped, a wart-hog with a broken leg. The animals bagged included antelopes and bucks of all sizes, and such different creatures as a crocodile, a bustard, a leopard, and a rock rabbit. Other sportsmen have been equally loud in praise of this weapon for game of a very different kind. Elephants have been killed with the head-shot with it, and it has been used with deadly effect against rhinoceros. One hunter has recorded, among other experiences, a successful "right and left" at buffalo with it. We may safely say that for such large game a different bullet is required from that suitable to the animals in Mr. Selous' list.

Imagine, then, two bullets of equal weight striking with an equally high speed a thin-

skinned animal, such as a small buck. Let them be bullets of the ·303, and let one of them have the nickel envelope locally weakened, as by being slit longitudinally near the head, or by having the envelope so arranged as to expose the lead at the point. With this bullet the resistance of the skin and tissues will suffice to cause its forepart to "mushroom" and break up, while the envelope covering it will be torn off and fly in fragments in different directions, so that veins, nerves, and arteries will be cut, and perhaps the heart or some vital organ reduced to a jelly. Let the other bullet be of a stiff make, as, for instance, enclosed in a thick envelope of steel or hard metal. This latter will not break up except upon striking a bone of such size as is only found in large animals. Need we dilate upon the results? The first bullet will inflict a vital wound, if it strike at all near a vital part. The second, if it perforate the heart or a large artery, the spine or the brain, will be fatal; but the chances are greatly in favour of its pursuing an almost undisturbed course through parts where it does no immediately fatal damage, and making its exit through a hole as small as that at which it entered, retaining even a good deal of its velocity. Indeed, the capacity which a bullet, if not broken up, has for avoiding the most

effective places is nothing less than astonishing. Not many months ago a man's arm was accidentally struck by a ·303 bullet on the rifle range. The bullet is said to have passed between the arm bone and the artery of the arm, and, luckily enough, to have inflicted the slightest possible damage, although the least deviation of it to one side or the other would have led to much more serious consequences, while a bullet of larger calibre must have damaged the artery. It is generally recognised by sportsmen that bullets always do their best to avoid a vital part when possible, and the injured man owes a great debt to their perverse ingenuity in this particular instance.

The trouble, then, in Chitral has arisen from our Service bullet being adapted rather for penetration into the bodies of large animals than for dealing with soft-skinned human game. The bullet has been made stiffer by thickening its envelope since the original trials of its destructive power, made before the rifle was adopted for the army.

The writer is indebted to the kindness of Mr. St. George Littledale, who so recently returned from a long and most perilous journey in the remoter parts of Asia, in which he penetrated Thibet to within fifty miles of Lhassa, for allowing him here to record in print his

experience of the ·256 Mannlicher during that expedition. Mr. Littledale has had much experience of Express rifles for a good many years, and has killed with them game of many kinds, such as the rarer sheep of the Pamir country, the aurochs—that last remnant of the wild ox of the ancient forests of Europe—and the wild camel of Central Asia. Here is the testimony he bears to the handy little rifle, with its flat trajectory. "The Mannlicher proved to be a terrible engine of destruction. The beasts seemed to be instantly destroyed. Not one in four moved its own length after being struck. And the striking was ridiculously easy, even at distances quite out of range of an Express. Given a good light and a stationary object, there really seemed no limit but that of sight." Mr. Littledale for three months depended on the rifle to supply meat for his party of thirteen, and puts the Mannlicher's share of the bag at about forty antelope and ravine deer, and five yak, besides a few sheep. He considers the flatter trajectory of the ·256 rifle, due to the higher muzzle velocity, to give it a very appreciable advantage over the ·303 in shooting game. The accuracy, too, of the rifle clearly left nothing to be desired.

It may here be observed that the bullet of the ·256 is enclosed in an envelope of steel,

which makes it very stiff; but that if the tip of it be filed so as to expose a small portion of the lead, the bullet at once has the tendency to break up, which makes it suitable for the game for which Mr. Littledale used it. It remains to be seen how far the smaller bore of ·236 inch, recently adopted for the United States Navy rifle, will maintain or even carry further the advantages obtained by reducing the calibre and increasing the velocity. Although it is clear enough that this process cannot be continued indefinitely, the signs of the times seem to point to the possibility—one might almost say the probability—that rifles of so big a calibre as ·3 inch will some day be considered old-fashioned large bores. And the time may come when rifles of larger calibre than this will be used only for dangerous or very large game.

There is one rather curious fact connected with penetration — that it does not always diminish as the distance increases. It may easily happen that with a high-speed projectile the actual penetration effected is more at a little distance than close to the rifle. This peculiar paradox, for which various explanations have been given, requires no theory of *vires acquirit eundo* to account for it. It will be seen at once that with any bullet made of such a soft substance as lead, the velocity, if increased beyond

a certain point, will tend to the breaking up of the bullet in forcing its way through a resistful material. This will happen if the resistance to the striking bullet becomes so great from the increased speed that the cohesion of its substance is overcome, and it "mushrooms" and expands; for now it cannot actually penetrate so far as if it had preserved its shape, even though moving at a lower velocity. In the latter case the particles of the opposing substance would have had time to be moved aside. Thus, the Small Arms Penetration Committee in 1893 found that in firing the Lee-Metford at walls of sun-dried brick, the penetration at 3 yards' distance was only 5 inches, but that it increased gradually to 15 inches at 400 yards, decreasing again from this point with increase of range. It was found that at the shorter ranges the bullet was deformed, while at 500 yards and beyond it retained its shape. Similar effects were obtained in firing into sand. The penetration into timber, on the contrary, was greatest close to the muzzle, as the bullet did not break up. At 100 yards it required 40 inches of deal or 21 of oak to stop the bullet of the ·303; that of the ·256 rifle needing as much as 45 of fir and 28 of oak. Consequently, against these bullets, trees of ordinary size give no effective cover.

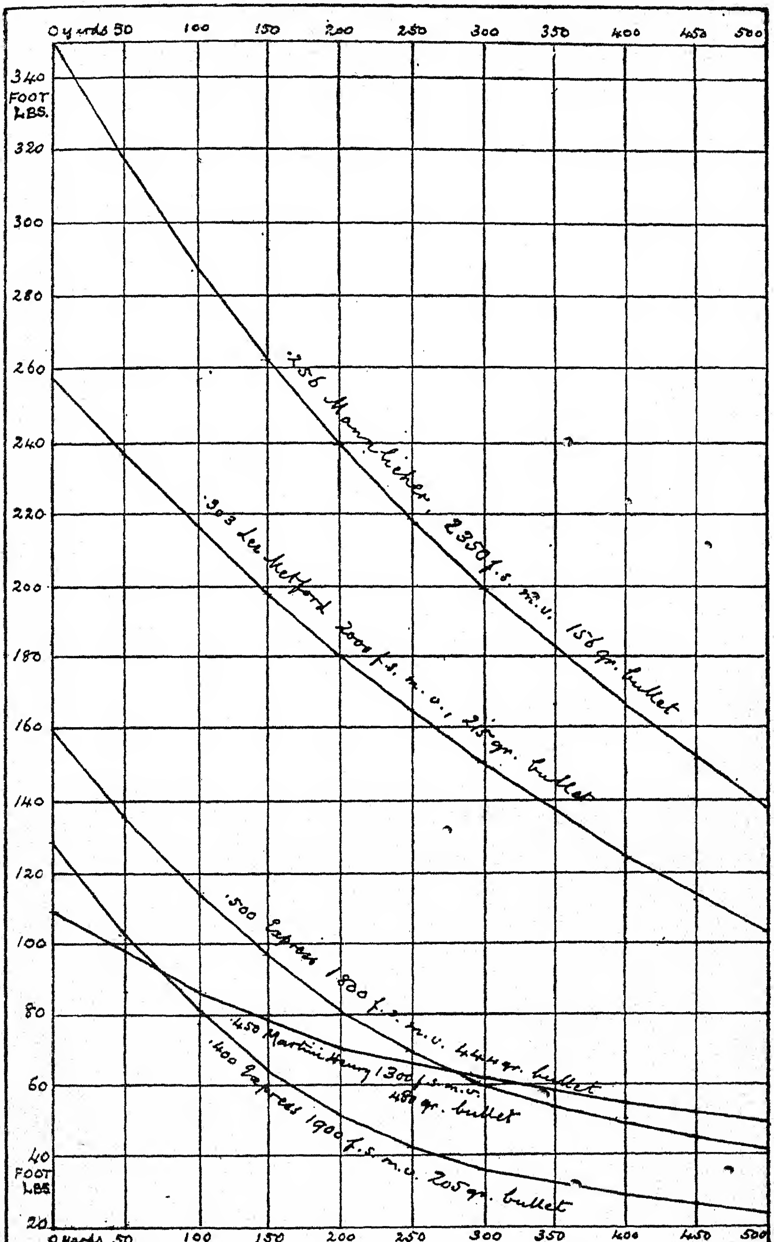


DIAGRAM OF PENETRATIVE INTENSITY

Showing in ft lbs the amount of the blow on an area $\frac{1}{10} \times \frac{1}{10}$ of an inch in the first 500 yards of the bullet's flight.

Of two bullets of similar shape, and giving equal amounts of energy, that which has the smaller cross-section will penetrate the further, always supposing that its shape is not distorted. This is because the blow is delivered on a smaller area, and thus its action is more concentrated, while the particles of the resisting substance which are forced aside or driven before the bullet are fewer.

As the force of wind is expressed by the number of pounds on the square foot, and that of steam or hydraulic power in pounds or tons per square inch, so we may compare the intensity of the blow given by different bullets when we know the energy and also the size of the bullet's cross-section. To complete, then, the series of diagrams relating to the velocity and striking energy of the rifles which have been dealt with, another is here added. That given on page 139 showed a comparison between the whole amount of the blow of the different bullets. That now given shows what may be called the penetrative intensity of the blow of the same rifles, that is, it shows the amount in foot pounds of the blow which each bullet gives upon an area of a given size. The unit of area which has been taken is the one-hundredth part of a square inch, that is, a square measuring one-tenth by one-tenth of an inch. So

small an area is taken because it would obviously be absurd to take a unit of area larger than the cross-section of the bullet of smallest diameter. The figures, then, are obtained by dividing the whole number of foot pounds of energy by the area expressed in inches of the cross-section of the bullet after it has passed through the rifling and been impressed with the grooves. Assuming the bullets not to be broken up, but to retain their shape on striking, the curves of the diagram will give a rough but not an unfair comparison between the penetration which we may expect to obtain, although, in fact, the smaller bullets are likely to have some advantage over the larger, beyond what is here shown, for the reasons already given.

Steel is still the best material for stopping projectiles, and from special steel of special hardness very great resisting power is now obtained. While it takes a thickness of ·44 in. of mild steel to be proof against either the ·303 or the ·256 rifle at 25 yards, a quarter of an inch of hardened steel is equally good against both. The Penetration Committee found that one of their plates of specially prepared steel, though less than a tenth of an inch thick, was capable of resisting all the bullets at 500 yards. It will be remembered how great a sensation was

produced some time ago by a German who brought to London and exhibited his so-called "bullet-proof clothing." This, when produced, resolved itself into a "cuirass," much too stiff and heavy for wear. It was oblong in shape, and large enough to cover the body; it was apparently about 3 inches thick, and looked much like a rather substantial carriage-cushion. Many experts were genuinely puzzled by it, but the inventor did not show the readiness to have it examined and tested by independent hands which might have been expected. Mr. Maxim, who is second to no man as a practical authority on the qualities of materials, promptly declared that a specially prepared steel was the one substance capable of affording, within the limit of weight given, the resistance shown by the cuirass. The pretence that the substance of the latter was of a fibrous nature, and not metallic, though upheld by explicit declarations that it contained no metal of any kind, became discredited when it was found that even the simplest electric test to prove the presence of metal was not faced. Finally, when the German inventor had filled his pockets with the gold of the British public, and returned to his happy Fatherland, some employé revealed the secret, and there were many who were not surprised to learn that a small steel plate in the

centre of the cuirass, with a rim round it to catch the splashes from the bullets, was the main element in the affair.

There is one caution to be specially given in connection with the small-calibre bullets. The ordinary iron plates used for targets are not equal to resisting the punishment they meet with from the new projectiles at short distances. Also, even if the target is sufficiently hard, the fragments of these bullets fly further and do more damage than the splash of the old-fashioned leaden ones. Hence it is well to shoot at canvas targets in front of a bank of earth, rather than at iron ones. Or, for practice up to 100 yards, a piece of cardboard with a bull's-eye painted or pasted on it, and fastened by tacks to a rail or board, makes the best possible target. Its life can be prolonged by covering the old bullet holes with stamp-paper, and if necessary pasting paper over it to give it a new face. Cardboard targets, a foot square, with a 2 inch or a 3 inch bull's-eye such as are used in the sporting rifle or revolver competitions at Bisley, may be obtained from any gunmaker.

It is well known that a bullet striking obliquely on a surface, whether of water or of some hard substance, glances off it and flies away, usually with a curious whizzing or scream-

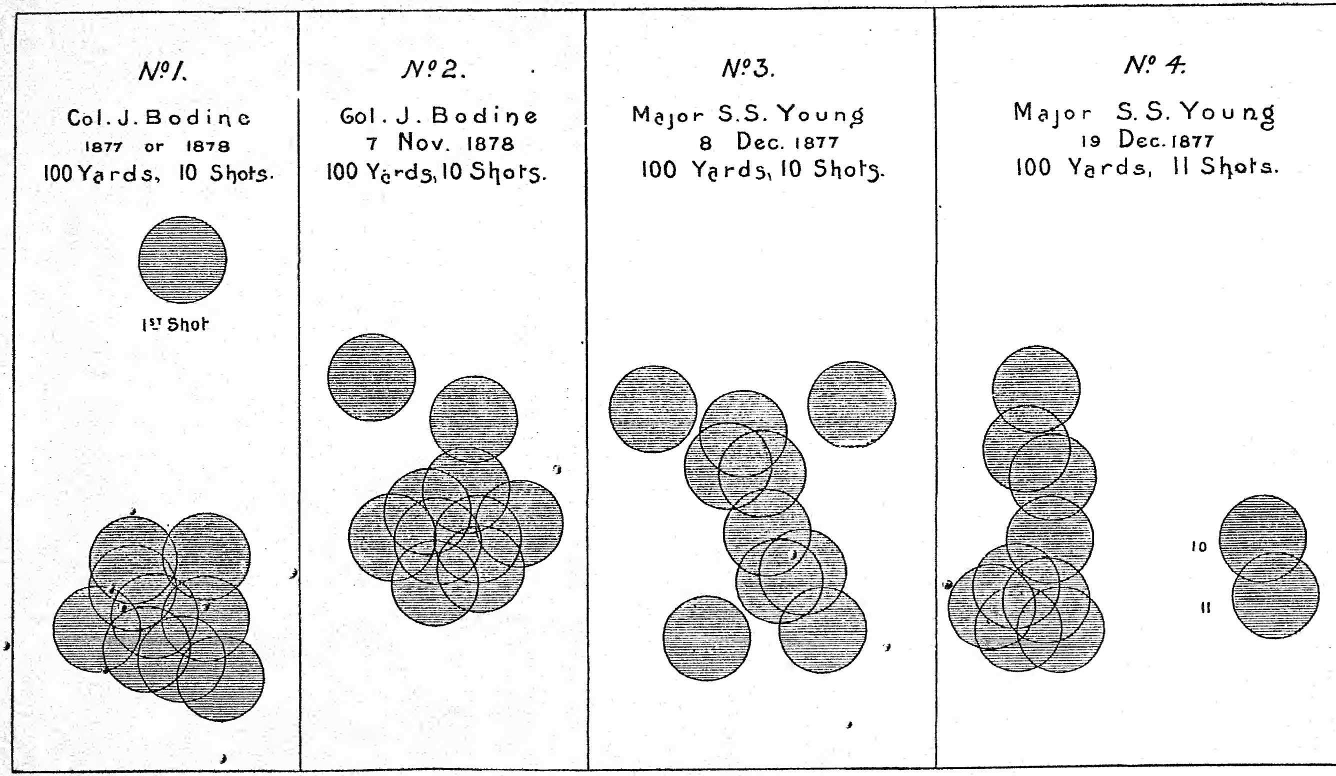
ing sound, caused by its losing its steady spin, and turning head over heels with great rapidity. A ricochet tends to diverge to the right when the rifle has a right-handed twist, and to the left with a rifle, such as is the Lee-Metford, whose spiral turns to the left. This is very noticeable in the case of shot from large guns fired at sea. Sir Joseph Whitworth found that the tendency to ricochet was much reduced with square-headed projectiles, as the taper head is one of its chief causes. He got good results in penetrating plates representing a ship's side under water, firing at such an angle as would cause a shot of the ordinary form to glance upwards off the water. Also his square-headed shot would penetrate armour plates when fired at quite an oblique angle. Their advantage for these special purposes, however, was not found to counterbalance the inferiority in flight necessarily given by the shape of the head.

CHAPTER XI.

Of Diagrams.

To attempt an account of great feats with the rifle is no part of our present scheme, interesting as it would be to do so. But it will probably interest our readers if, by way of a conclusion to the present series of Notes, some instances be given to show the degree of accuracy which may be expected under the best conditions from modern weapons. The writer makes no apology for giving diagrams of the authenticity and accuracy of which he himself is thoroughly satisfied, although they may not have been made in public competition.

These examples may be considered to be about as good as can ever be expected, even by firing the rifle from a mechanical rest when the best atmospheric conditions prevail. The shooting here represented was, however, done either in the lying-down position commonly used for match-shooting, or with a table rest, which affords support to the arms and to the



DIAGRAMS, 100 YARDS RANGE.

barrel of the rifle while it is fired from the shoulder. The diagrams of shooting at 100 yards are, therefore, not on a fair basis for comparison with any of the sporting-rifle diagrams made at the Bisley meeting in the Martin Smith and similar competitions, the shooting in which is done in the sitting position. The extraordinary accuracy obtained under this disadvantageous condition by experienced marksmen, such as Sir E. Loder, Mr. Joynt, and Captain Dutton Hunt, is as great a testimony to the skill of the men themselves as it is to the perfection of the weapons which they use.

For the first four diagrams, those made at 100 yards, which are given of their full size, the writer is indebted (among many kindnesses both great and small) to Sir Henry Halford, an old sportsman, whose name has been prominent in the rifle world for five-and-thirty years. Less than three years ago he showed at Bisley that among all his competitors of a younger generation there was none whose skill was not inferior to his own. The first two of these diagrams were made by Colonel J. Bodine, the well-known American shot. No. 1 was made in either 1877 or 1878, with a Sharps-Borchardt breechloader, which was wiped out between the shots. The load was 100 grains

of Hazard F.G. powder, and the bullet weighed 550 grains. The firing was done from a table rest. Colonel Bodine, in a note appended to the diagram, mentions that for the first shot the barrel of the rifle was supported at a point only 2 inches from the muzzle, and that then, the point of support being shifted some 10 inches further back, the remaining nine shots grouped themselves in a different place. Certainly these nine, which can be completely covered with a penny, form as close a group as can well be imagined. They would all have struck a threepenny-piece.

The diagram marked No. 2 was made by Colonel Bodine at his place, Highland, on November 7th, 1878, with a Borchardt breech-loader, cleaned between the shots, and loaded with 103 grs. of Hazard powder and a bullet of 550 grs. This diagram was not made from a rest like the previous one, but in "the long-range position"—doubtless some variety of the back position. All these ten shots would have struck a shilling, and nine of them a three-penny-piece. To make such diagrams as these requires not merely that the marksman should be in first-rate trim, and aim and pull every shot with the greatest nicety. Nor does it merely require in addition a very perfect weapon and ammunition of great excellence.

It needs, further, the luck that for the series of shots all should go perfectly, and no change of wind or slight deviation, such as too often happens from some small cause that is quite unaccountable, interfere to rob the marksman of complete success.

It would seem that the same attention has not been given in this country as in America to match-shooting at 100 yards, but Sir Henry Halford's records at Wistow contain the actual targets represented by the next two diagrams. These are due to the skill of Major S. S. Young, well known as an expert in rifle shooting of all forms. His success with the weapon in Indian jungles in his earlier days was, the writer believes, no less than that which for so many years made him one of the most conspicuous figures on Wimbledon Common. In the course of a prolonged trial at 100 yards of various match-rifles, both English and American, which was carried out at Wistow in the winter of 1877-8, these two diagrams were the best obtained. They were both made—to the credit of the old country be it said—with Metford rifles, and were made without any artificial rest, Major Young using that form of the back position which is known as the Fulton position. The first — No. 3 —was obtained with a muzzle-loader, with 90

grs. of Curtis and Harvey's No. 6 powder and a 540 grs. Metford bullet. The rifle was cleaned between the shots. The mean deviation of this group is ·475 inch, and the ten shots would all have struck a penny.

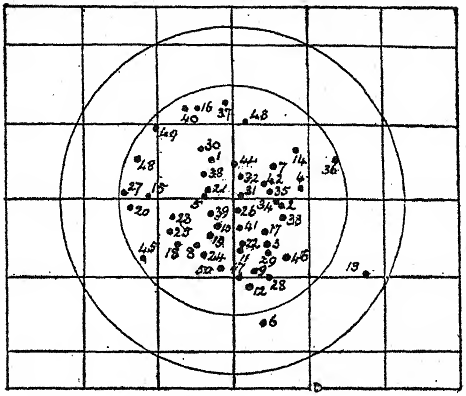
The diagram numbered 4 was made a few days afterwards with a Metford breechloader, loaded with 105 grs. of Hazard (American) powder and a Metford bullet of 540 grs. The rifle was cleaned, as before, between the shots. This diagram would, no doubt, have been well ahead of No. 3, had not an unlucky mishap occurred to spoil it. The nine shots which form one long hole in the paper target were the first nine fired. The tenth went, as shown, wide of the group to the right. After leaving the range, Major Young came to the conclusion that his fore-sight had been accidentally shifted after the ninth shot, and confirmed this by returning and firing an eleventh shot, which, as shown, cut the tenth, thus verifying his conjecture, and at the same time great accuracy of his aim.

It may possibly appear to some readers that these diagrams are hardly so good as they would have expected. But anyone who wishes to do better, especially without such aids as telescopic sights or a machine rest, will find that he has his work cut out for him. At the

The bullseye is 3 ft. in diam^r., & the squares represent 1 foot square.

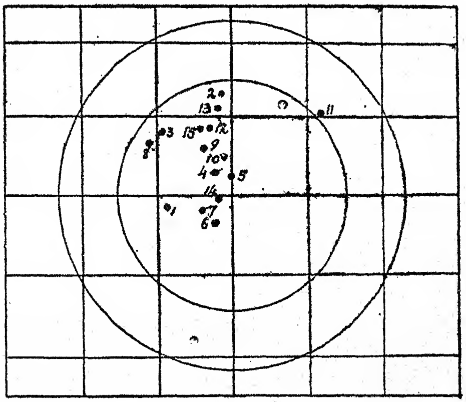
No. 1.

50 shots at 1000 yds, fired at Wistow 11 Oct. 1886, by G. C. Gibbs, with a ·461 Metford Match Rifle. Curtis & Harvey's No. 6 powder, bullet 540 grs.



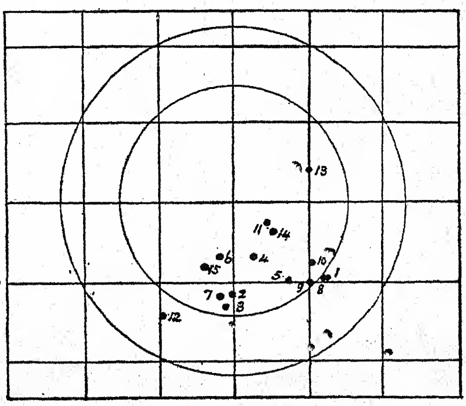
No. 2:

15 shots at 1000 yds, fired at Wistow 17 Oct. 1894, by T.F.F., with a ·461 Metford Match Rifle. Cannonite powder, bullet 540 grs. copper clad.



No. 3.

15 shots at 1000 yds fired at Wistow by T.F.F. 8 Oct. 1895, with a ·303 Lee-Metford Rifle. Cannonite powder, bullet 200 grs, copper clad. Match sights were used.



DIAGRAMS, 1,000 YARDS RANGE.

same time, the writer is disposed to think that the accuracy of the new small-bore rifles, which have the advantage of smokeless powder, is, with proper ammunition, superior, if anything, to that of the ·45 and ·461 rifles with which the diagrams here given were made. He much regrets that he has been unable to obtain any pictorial record of work of the Kentucky pea-rifle, which was supposed to be able to "drive the nail" at 100 yards. Nor has he been more successful with regard to the shooting of the Tyrolese, who certainly had in old days excellent rifles, and, by the aid of hair-triggers, made wonderful practice with them in the standing position.

There are rifles which will make good shooting at short distances, but seem rapidly to fall off in accuracy at long ones. But, generally speaking, a rifle or a charge that gives good results at short range will give results proportionately good at an increased distance. And, at long ranges, the difference between good and second-rate work is much more obvious than at short. Hence, long-range trials have a decided advantage for experimental work, although even more than at short ranges it is necessary to discount the effect on the diagram of changes in wind and weather during the shooting. Such work as is next exemplified

has a very real value, as it is only by careful experiment that the highest possible results can be obtained, from which (for instance) we may learn what standard of accuracy may fairly be laid down for ammunition made in large quantities.

Without entering into the subject of the large scores which at one time and another have been made at long ranges, it may be well to give examples of what is the best work that under the most favourable circumstances can be got from rifles at 1,000 yards. The first target given has appeared in print before, and it is beyond doubt the best piece of shooting at 1,000 yards that has ever been made in this country. There seems no reason to believe that it was ever equalled by any performance in America. To put forty-eight out of fifty consecutive shots into the 3-foot bull's-eye is a feat which combines a very high degree of skill with some good fortune. The bull's-eye on Sir Henry Halford's range consists of a steel plate hung in front of the target. It has had many thousands of shots fired at it at 1,000 yards, during a period now of more than thirty years, but only on this one occasion has it responded with its musical sound thirty-seven times running. The weather was very favourable—there was only a slight drift of wind—the light

being steady and not too bright. A bright glare is apt to tire the eye in a long series of shots, and a rather dull—even slightly hazy—light is the best. The strain on the attention, and the anxiety to fire every shot perfectly, make it a great effort to fire a long string of shots, especially when the winning of a match or the cutting of a record depends upon each pull of the trigger. Captain Gibbs is one of the men whose self-command in such circumtances is entirely to be relied on. It is noteworthy that the rifle with which this target was made was an old one, and had previously had some 20,000 shots fired from it. It was not cleaned during the shooting.

No. 2 and No. 3 diagrams are given as examples of exceptionally close grouping of shots at 1,000 yards. Needless to say, they were not made in difficult weather. The records of competitions at Bisley and elsewhere can no doubt produce plenty of examples of twelve or fourteen out of fifteen shots striking the bull's-eye. The object in view, however, in these instances, was not so much to make bull's-eyes as to fire a series of shots with the same aim, in order to see how small a group the shots would make on the target. Viewed in this light, No. 2 is very remarkable for the close lateral packing of fourteen out of the fifteen

shots, but the vertical deviation of the group is not so small as may occasionally be obtained. The writer has never seen a closer group made. The mean deviation of the fifteen shots is only 7·4 inches. Oddly enough, this target was obtained on the first trial of a new load of smokeless powder.

The bullets of the ·303 and ·256 inch rifles are very light in proportion to the surface which they expose to a side wind, and are therefore much more susceptible to its influence than the heavier ones of the match rifle, although in a given distance the latter have a slower flight and rise to a greater height. The bullet of the ·303 requires 30 to 40 per cent. more wind allowance for a side wind than that of the match rifle, but is less affected in elevation by front and rear winds. In calm weather the ·303, with good ammunition, is quite capable of holding its own against the match rifle at all distances. The writer has several times seen fourteen bull's-eyes and one inner made with it in fifteen shots at 1,000 yards, and has, on more than one occasion, done good work with it at 1,100 yards, the furthest range ever used for individual competitions. It will be noticed in diagram No. 3 that no attempt was made to bring the shots to the centre of the bull's-eye, but that the group was

allowed to form itself near the bottom of it. The weather was by no means so calm as when No. 2 target was obtained, and the group is more spread laterally. But its vertical component is better than that of No. 2. The mean deviation of the fifteen shots is 8·9 inches. The first ten form a very remarkably close group, having a mean deviation of only 7·6 inches, and are all within a vertical height of 8 inches, less than the height of a page of the present volume, while the breadth of the group is less than double the height of the page. Like the ·303, the ·256 Mannlicher is capable of making very fair shooting at these long ranges, although the writer has had no results from it which will compare with the targets last given.

And now it only remains to add a word of thanks and one of farewell to the indulgent reader who may have followed, however cursorily, these Notes. If he be already a marksman and a sportsman to boot, may his eye be keen and his hand steady for many a long year to come! For such there can be no better wish than that he may have, in the words of the Jungle-folk's salutation, "Good hunting." If, being a marksman, he yet lack time or opportunity to exercise his skill in the field, may the white disc or the black panel often

rise up to signal the bull's-eye when he fires, and may his knowledge increase, and his success with it, as time goes on! And to him who has never learned the use of the grooved arm we would appeal, if by any means he can so mould his circumstances as to serve his apprenticeship to the art, to make a special effort to do so. There is scarcely anyone who cannot with a little trouble attain a fair degree of proficiency, and the time spent in acquiring it will never be regretted. The scarcity for the average Englishman of the opportunity to learn is indeed deplorable. Those, then, who can make for themselves the opportunity are doubly bound to use it, for the rifle is no mere toy. It is the last arbiter of international quarrels, and a main basis of our security at home and abroad. Englishmen cannot afford to neglect its use, if they wish to see their country maintain unchallenged her proud position as the strongest and the most generous of civilised nations.

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